'Distils a century of modern neuroscience into a remarkably fast-flowing and easy-to-read synthesis that describes what our brains do and how we can get the most out of them'

Professor Karl Friston FRS, Wellcome Trust Centre for Neuroimaging, University College London

DR JACK LEWIS & ADRIAN WEBSTER

SORT YOUR BRAIN OUT

SECOND EDITION

BOOST YOUR PERFORMANCE, MANAGE STRESS AND ACHIEVE MORE

"This truly inspiring and fascinating book leaves you never wanting to waste a single second ever again. Everything you need to know about how your brain works and how to maximize it is contained in an easy-to-read way. The book proves you really can do anything and there are lots of simple ways to help ensure you too can make the most of your biggest asset – your brain! Without doubt, a book you cannot be without!"
Dame Sarah Storey, DBE

"For all the debate about governments nudging people to make better decisions or to adopt better behaviours, it is easy to overlook the fact that we can actually nudge ourselves. This book is a wonderful guide to how to do just that."
Rory Sutherland, Executive Creative Director and Vice Chairman, OgilvyOne London and Vice Chairman, Ogilvy Group UK

"I thought it was accessible, thought-provoking and full of useful, easy-to-follow tips about improving your everyday life through a better understanding of the brain."
Killian Fox, writer for *The Observer* and *The Guardian*

"A really great book that explains in layman's terms how the brain works and how you can then translate that knowledge to enhance your own performance. Thought-provoking and insightful, it will add considerable value to anyone still willing to learn, irrespective of which rung of the success ladder they are on. It's an enjoyable and extremely useful read."
Mark Hussein, Global Head of HSBC Commercial Insurance and Investments

"*Sort Your Brain Out* is a must-read for everyone. It is a clever and thoughtful book designed to help the lay reader understand more about the brain's most intimate workings but most importantly it provides erudite yet easily consumed bite-sized gobbets of information on how to improve one's lobar lot. The fascinating examples are eminently readable and marvellously memorable; the reading of this book will stretch the brain in exactly the way the authors have devised. This is mental stimulation at its best."
Chantal Rickards, OBE, former CEO BAFTA Los Angeles

"As someone who has spent their life reviewing neuroscience material, I was struck by how the overview on offer contextualises some aspects of brain function in a novel and refreshing way.

In short, this is a delightful and illuminating read – it is the book that I would (will) give my family, when they ask searching questions about neuroscience – and what it means for them."
Professor Karl Friston FRS, Scientific Director, Wellcome Trust Centre for Neuroimaging, University College London

"*Sort Your Brain Out* has clarity of purpose and many features that puts it ahead of its competitors in an expanding area of interest. Making the best use of the amazing brains we all inherit, even though they are destined to operate in a world far removed from the environment that shaped their evolution, is crucial. There probably is no more important a task for us as individuals or for the groups we live and work in than this. Help and the chance to expand our insight is at hand."
Ian Edwards, Connection Planning Director, Facebook

"Engaging, accessible, demystifying."
Dr Daniel Glaser, Director of Science Engagement, The Royal Institution

"This book explores the kind of topics we all think and talk about: Is the internet making us stupid? What do alcohol and caffeine really do to our brains? It provides you with exactly the kind of fascinating nuggets of information you end up reading out to whoever you happen to be with, as well as practical tips on how to maximise what we all have between our ears. Forget brainstorming, it's all about brainshaking and dunking now. Neuroscience demystified and simplified without being patronising; a must-read."
Olivia Walmsley, Head of Digital Lifestyle, The Telegraph

Sort Your Brain Out

SORT YOUR BRAIN OUT

Boost your performance, manage stress and achieve more

Second Edition

Dr Jack Lewis
Adrian Webster

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What This Book Is All About

Every human being on this planet has the most incredible apparatus in the known universe swimming around inside their skull. Yet despite its unique capacity for working out what makes things tick, the vast majority of users are completely unaware of its stunning capabilities, let alone its tremendous capacity to adapt to the world we live in.

The human brain is able to adapt to the demands of pretty much any environment, from the isolated regions of the arctic tundra and the jungles of the tropics to the densely packed cities and even the virtual worlds online. It physically changes its circuitry to slowly but surely improve performance in more or less any behaviour that is regularly required of it. It adapts itself in a way that enables a huge variety of skills and abilities to become quicker, more accurate and more efficient the next time you come to do them.

This process of rewiring for self-enhancement is so gradual that the day-to-day improvements are usually imperceptible. Only if you continue to perform that behaviour intensively (not too easy, not too hard), regularly (ideally daily) and consistently (over an extended period of weeks and months) will your brain change sufficiently for the improvements to become noticeable.

But brains don't only adapt to accommodate good behaviours. Brains adapt to perform any regularly repeated behaviour more efficiently, whether it's in our long-term best interests or not and either way we usually end up carrying out such highly practised behaviours without giving it much thought at all. Whether it is something useful like safely steering a car down the motorway while your attention is completely focused on an absorbing podcast or radio show or not-so-helpful like helping yourself to

that second slice of cake, your behaviour is largely controlled by a brain operating entirely on autopilot – for better and for worse.

The aim of this book is to inspire you to consider the tremendous impact that neuroplasticity – your brain's ability to physically change to deal with pretty much any set of circumstances – can have on your behaviour and to help you grasp that current beliefs and set-piece behaviours were originally formed according to a series of chance events that happened to occur in your past and the stories that you regularly encountered in your daily life prior to now. Equally, future beliefs and behaviours will be formed according to whatever thoughts, people and places you choose to regularly, consistently and intensely engage with from now on.

Your brain is constantly upgrading the circuits inside your head that are often used and downgrading the neglected ones, every single day. Whether these changes lead to benefits or drawbacks is entirely under your control. It all boils down to spending more time in places – both real and virtual – that gradually enhance your cognitive powers and emotional well-being and less time in those that degrade it.

By giving people a clearer understanding of how their own brains work and by changing the common but false perception that "you can't teach an old dog new tricks," the main objective of this book is to harness the revelation that we can fundamentally change the very fabric of our brains, all the way through adulthood. As a result we can subtly alter our habitual behaviours, beliefs and motivations, and eventually bring about profound positive change. This book provides you with a wide range of simple brain-enhancing tools and practical tips to do just that.

In the years that have elapsed since publication of the first edition, new research from the worlds of neuroscience, psychology and the medical sciences has hit the academic press. This has brought with it yet more clues about the many things we can all do to get more out of our brains on a daily basis. It has resulted in new additions for some of the original chapters and three brand new ones. So there are even more easy-to-follow brain optimisation principles (BOPs) for you to get your teeth into than ever before.

Introduction

Many people have a burning desire to be successful, some even have the know-how. For those who don't there are literally thousands of self-help books out there, telling them how.

Yet, despite tsunamis of ambition and an abundant supply of well-meant advice, only a few people achieve real success and even fewer manage to maintain it.

The main reason is that despite being the most sophisticated piece of bio-wetware in the known universe, capable of running the most phenomenally complex software, your brain doesn't come with a user guide.

Millions of people spend their lives scurrying around, all revved up, trying to get somewhere and devouring huge volumes of information on self-improvement. Yet they don't have a clue about the engine under their bonnet, the nature of its profound capabilities or how to get the best out of it.

In other words, they – as captain of the ship – may have all the drive, passion and heart's desire in the world to set and maintain a particular course, but if the engine room can't deliver, they'll be left wanting, drifting in the doldrums of success.

Most take their brain for granted. Some even forget it exists. Others spend hours in the gym working away on the bodywork. But only a few realise just how much more they can get out of themselves with a basic understanding of their brain and a small amount of care.

In this book, we will help you to get a better understanding of how our brains actually work and explore ways of consistently getting more out of our own – often idling but potentially brilliant – high-performance engines. Hopefully, we'll be able to help you achieve more with yours, whoever you are.

A bit about us

We first met back in January 2011 when we were both invited to speak at a conference in Tenerife. The theme of the event was "Are You Ready?" Our task was not only to inspire those attending but also to offer useful, practical guidance to help them be prepared for the tough challenges that lay ahead and enable them to capitalize on any opportunities heading their way.

As two very different people – with very different backgrounds and very different life experiences – we found ourselves working together delivering complementary messages, but from completely different perspectives. It was then that we realized just how impactful our combined knowledge could be and what a difference it could make to people at work and in their everyday lives.

Where Adrian's coming from

As a motivational business speaker I'd like to think that I am a highly motivated person; I'd be in the wrong job if I wasn't. I'd also like to think, having written self-help books, that I have a fairly good idea of what it takes to be successful.

Despite being a reasonably fit, fairly intelligent and relatively successful person with bags of self-drive and years of practical experience, especially when it comes to developing winning attitudes, I was keen to find out more about the hardware that supports the software – the engine that runs my mind.

I wanted to know more about my own brain, learn how to help it be even more productive and hopefully keep it in full working order for many more years to come.

Like you, I live in the real world. I run around at what often feels like a thousand miles an hour, juggling family, work and social commitments. There are times when, even as a motivational speaker, I feel a bit run down – especially when doing a lot of travelling. The gym can at times be very unappealing and with my batteries running low I don't always feel as mentally sharp as I'd like to be.

As a writer I sometimes find it hard to be as creative as I know I can be and despite having clear goals it can be difficult to stay consistently focused. On top of all this, when I do get to spend time with the most important people in my life – my family – it can be a struggle some days to unwind; my overworked brain just doesn't seem to want to stop revving!

As an everyday person I wasn't under any illusion that overnight I'd suddenly gain the combined planet-sized intellectual skills of a mathematical genius, the creativity of a Renaissance master and the single-mindedness of an Olympic athlete. I just wanted to sharpen up a little, consistently have more energy, hopefully stay focused for longer, be a touch more creative and enjoy quality time with my family. At the end of the day, I just wanted to make the most of the one I've got.

As a lifelong learner I'm not ashamed to accept all the help I can get, so I decided to team up with TV's favourite neuroscientist, Dr Jack Lewis, to see just how much of an improvement I could make to my own brain. I'm pleased to report that his practical advice has had an extremely

positive effect and I have already noticed a tangible difference in my brain's performance.

As we progress through this book together, looking at ways to optimize the capabilities of brains, Jack and I are going to share with you all the practical advice that he had to offer me and, at the same time, draw on our diverse experiences to give you some helpful suggestions about how you, too, could improve the performance of your brain. Hopefully you'll take them on board, start using them and see what a difference they make to you.

For more information about Adrian – please visit: www.adrianwebster.com or tweet @polarbearpirate

Where Jack's coming from

Biology was by far my favourite subject at school. My fascination with what makes us tick took me into the realms of neuroscience, first at the University of Nottingham, then University College London (UCL) and later at the Max Planck Institute for Biological Cybernetics. The latter involved post-doctoral research using Magnetic Resonance Imaging (MRI) to plumb the depths of the multisensory human brain. By the time I published my research in a decent scientific publication (*Journal of Neuroscience*) I realised that the time had come to move away from doing my own research – as I'd discovered my true calling.

Since starting my doctorate at UCL in 2002, what started out as a minor frustration had blossomed into an itch that I just had to scratch. The neuroscience literature is full of fascinating revelations about how the mysterious organ between our ears does what it does. Hidden between the lines of the various neuroscience research papers I was reading on a daily basis (and still do) were pearls of wisdom that I'd started using to get more out of my own brain. It seemed a shame to keep this all to myself. And as nobody else seemed to be doing it, I was determined to do everything I could to get these insights out into the real world: practical

tips and tricks regarding what we can do, every day, to nudge our brains closer to our own personal maximum potential.

To date, I've shared insights into how our brains work with millions of viewers across the world via TV series on BBC1, BBC2, BBC World, ITV, Channel 4, Channel 5, Sky One, National Geographic, Discovery Science, TLC, MTV and most recently two series on Insight TV. I've also written two other popular science books as well as this one. And since that fateful day in Tenerife, I've now given over a hundred talks at individual businesses, and various industry conferences, helping all sorts of audiences improve their health, happiness and productivity.

For years I had a burning ambition to write a book that explained to everyday people how their brains work and how to get them firing on all cylinders. Thanks to Adrian, who'd already established himself as a best-selling author, I finally got the chance to write this book. Ever since we got together to write the first edition, merging the worlds of neuroscience and business motivation, we've been passing on compelling, much-needed, some might even say *essential* brain user information to thousands of people all over the world.

I've been absolutely blown away by the positive feedback we've received over the past few years! Whether from people who'd read the book and found it really helped them or those who hung out with us at the end of a talk to ask a brain question or two, it has been extremely rewarding to hear how much people got out of the first edition. Given how well the first edition went down and with so many exciting new insights to have emerged in the scientific research literature since then, we're hopeful that this second edition will go *even further* in helping everyone to get the most out of their brain at work, rest and play.

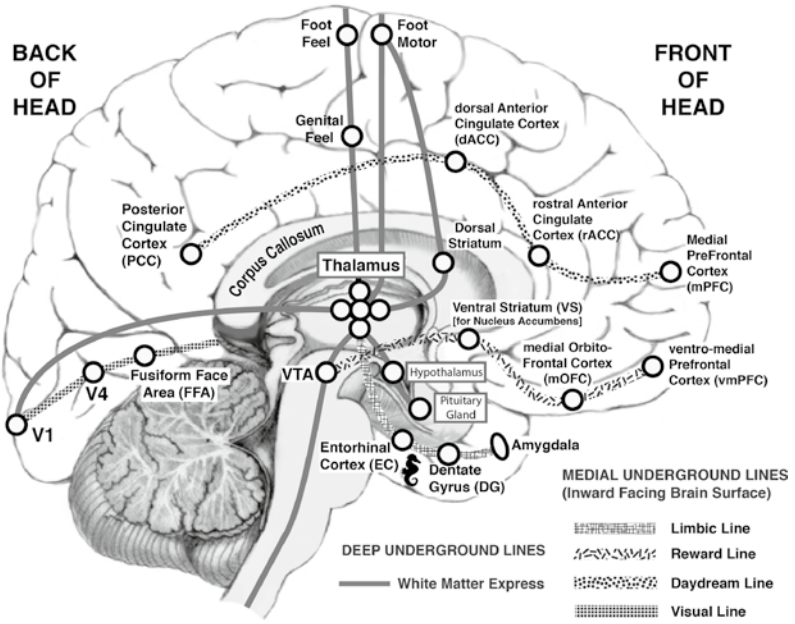
For more information about Jack, please visit: www.drjack.co.uk *or tweet @drjacklewis*

Your Amazing Brain

The word "amazing" seems to be used pretty loosely these days to describe a lot of things, many of which often turn out to be disappointingly mediocre, but in the case of your brain there really is no other word that does it justice.

This wrinkled pink lump of pulsating wetware has a texture not dissimilar to blancmange, is composed of around 80% water, 11% fat, 8% protein, 3% vitamins or minerals and weighs in at around about 1.5kg. It is a densely woven meshwork of 86 billion brain wires (neurons) along with a further 86 billion support cells (glial cells), all neatly packed away in the cavity between your ears. It is *truly* amazing.

As the ultimate supercomputer, your brain is currently light years ahead of anything that humans have so far managed to create. It works relentlessly, nonstop, around the clock, continuously reshaping to adapt our skills and behaviours to suit an almost infinite variety of different real and potential future circumstances, receiving and delivering data, analysing information, performing billions of complex, multifunctional tasks in parallel and monitoring millions of functions, all at a breathtaking speed. Its capabilities really are quite staggering.



When it comes to high performance, what does your brain look like?

The map in the illustration above shows some of the stops on the underground system that runs right down the middle of your brain, level with your nose. This particular image is referred to as the "Inward-Facing Brain Tube Map" because it shows the inner brain surface, where the left and right hemispheres rub up against each other along the midline. It's duplicated at the back of the book – in the Appendix – so you can find it again more easily. You'll also find an "Outward-Facing Brain Tube Map" there too. Both maps are also available at www.sortyourbrainout.com for anyone listening via audiobook.

No benefit would come from overloading you with unnecessary information by talking about every area of your brain, but it *would* be useful to start by pointing out three key areas that are most relevant to what we'll be discussing in this book. The hippocampus includes the DG (Dentate Gyrus stop) and EC (Entorhinal Cortex stop) on the lower part of the Limbic Line, a particularly dense area of networked brain wires connected with virtually every other part of your brain.

Why a seahorse?

You may be wondering why there is a seahorse in the illustration of this medial surface (inward-facing) tube map of the brain. If your brain's hippocampus was surgically removed from the inward-facing surface of each of your temporal lobes, you'd see that they actually look very much like a seahorse. Indeed, the word "hippocampus" comes from the ancient Greek *hippos* ("horse") and *kampos* ("sea monster").

This part of your brain performs three key roles:

1. It helps you to keep track of where you are – a GPS system of sorts that gives you a sense of where you are and how to get where you're going.

2. It enables you to create and recall memories of events and pieces of information, so it's essential for the accumulation of knowledge and the ability to learn from experience.

3. It's even vital for our ability to imagine the future!

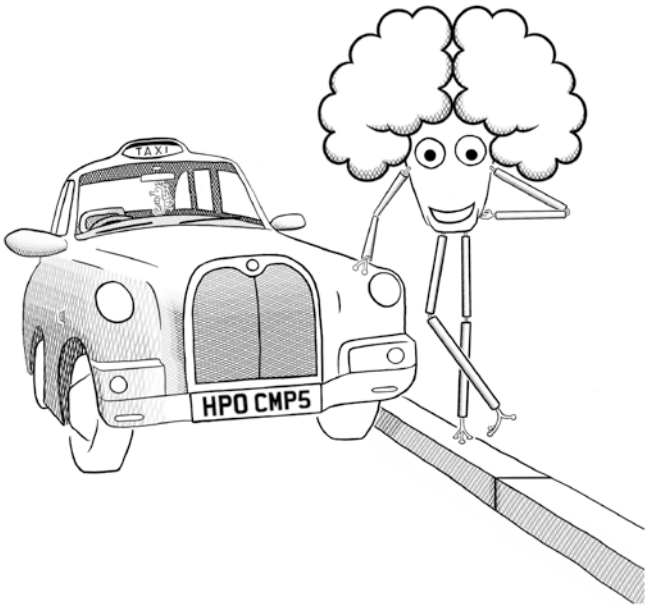
The first two of these functions are intimately related, as many of our memories of life events are closely intertwined with the places in which they were experienced. This is why, when you return to that place, the most relevant memories will be triggered. Hence a visit to your old primary school can produce a surge of long-forgotten memories. The hippocampus cluster of tube stops in your brain is buried deep down within each of your temporal lobes. These run along the left and right sides of your brain, from just above and behind the ears to the temples of the skull.

Taxi!

The drivers of London's famous black cabs spend, on average, 2.2 years learning "The Knowledge," a seemingly unconquerable mountain of information to commit to memory by anyone's standards. Without looking at a map, they need to be able to describe how they would use the 20,000 major routes *and* the whereabouts of 25,000 places of interest that a fare-paying passenger, having hopped into the back of their cab, might want to visit.

During this period of exhaustive information ingestion, the rearmost parts of the hippocampi of these wannabe cabbies grow physically larger due to all the extra connections required to retain that information – only to return to their normal size shortly after retirement. It really is a case of use it or lose it!

What this shows is that your brain not only adapts to take on new challenges, but it physically restructures itself to meet them. As yet, there is no computer capable of reconfiguring itself in this way to cope with new demands asked of it. Not bad for a design that first appeared on the scene back in the Stone Age and which still outcompetes the most complex computing systems of the modern age (for the time being at least)!



Just beside the DG stop you'll find the amygdala tube stop. This ever-alert brain area is responsible for, among other things, generating various emotions and constantly monitoring the sensory information being captured from your surroundings for signs of potential danger. Like a military listening post for your brain, it is forever looking out for possible threats to your well-being, always primed and ready to push the "big red button" that orchestrates the feeling of fear a split second after possible danger has been detected. This is the part of your brain that, within less than a semiquaver of time, having heard a loud bang or spotted a rapidly approaching object coming your way, causes you to freeze in your tracks, duck out of the way or simply jump out of your skin – before you're even fully aware of what it is you're dodging. With your heart now pounding and your muscles flooded with blood, you're all set: ready for a confrontation or a hasty exit.

During early pregnancy 250,000 new neurons are created in the foetal brain every sixty seconds!

Just above the amygdala tube stop is the Reward Line. It evolved to trigger pleasurable sensations whenever you engage in behaviours that promote the survival of the species (i.e. eating, drinking and having sex). Known collectively as the reward pathway – the VTA (Ventral Tegmental Area), VS (Ventral Striatum) and OFC (OrbitoFrontal Cortex) stops – are also critical to decision-making.

The VTA stop in the midbrain – just above the brain stem – is the starting point of the Reward Line and is where all of the brain's dopamine is manufactured. While dopamine is involved in helping the right messages reach their intended destinations in many separate brain pathways, each playing a different role in overall brain function, the VTA itself is reliably activated by life's pleasures.

The responses of the next stop on the Reward Line – the VS stop, which contains an important structure called the nucleus accumbens – are a bit more sophisticated. Rather than just being involved in triggering rewarding feelings in the moment of doing something pleasurable, it provides a *prediction* of which of a range of available options is likely to trigger the greatest reward in the *future*. This means that the Reward Line is not only instrumental in helping us make every single decision we make, but it is also fundamental to the process of learning to make better decisions. Whenever our decisions deliver a reward that is smaller than or greater than the anticipated reward, the Reward Line system updates its predictions accordingly. Without the reward pathway, we would never learn from our mistakes!

> There are more connections between brain wires in your head – 150 trillion synapses – than there are stars in our galaxy (the Milky Way).

To help give you a clearer perspective on what we're looking at here, the London Underground proudly boasts a combined track length of 250 miles, with hundreds of tube trains travelling between the 270 stations at a top speed of about 70 mph. But that's a damp squib compared to the information-transporting networks you're packing deep inside your skull.

If all your brain wires were laid out end to end, they would be approximately 100,000 miles in length, with hundreds of thousands of trillions of trains (electrical messages) travelling up and down, bang on time, at up to 250 miles per hour, shuttling information towards the 0.15 quadrillion connections (synapses) that reside in your grey matter. And, if all these wires – your brain's white matter – were laid out as an underground train network, it could cover an area of around 560,000 square miles, a surface area larger than the whole of South Africa, all tucked into a space smaller than your average pumpkin.

What really makes the human brain so very special is NEUROPLASTICITY – its ability to physically alter its pathways, as you learn new skills and, perhaps even more importantly, its ability to adapt to unexpected changes, under widely varying circumstances, in new and creative ways.

Your brain can send these one hundred, thousand, trillion messages per second using the same amount of power as your average fridge light bulb. For a human-made supercomputer to send and receive that many messages per second it would require its own small power plant to provide the 10,000,000 watts needed to power it. Less than a litre of blood passing every minute through the brain of chess grandmaster Garry Kasparov was sufficient to keep his forehead merely warm to the touch, whilst his opponent – the IBM supercomputer Deep Blue – needed a vast fan-driven cooling system to stop it blowing up.

It doesn't come with a guarantee or any warranties, but if you look after your brain, it should remain fully functional and in good working order throughout your entire lifetime. And if you're ever worried about running out of memory space, please don't! You'll be relieved to hear that it comes with the equivalent memory space of a one million gigabyte computer chip. That's enough memory to record over three million hours' worth of your favourite TV programmes.

When we sleep, our brain cells shrink. This makes the concentration of the substances swimming around in the fluid *inside* the cells higher than those in the fluid *outside* them. This flushes out the metabolic waste materials that accumulate each and every day within our brain cells, which are then banished from the brain via the newly discovered "glymphatic" waste removal system. More sleep, more toxin removal.

Your brain is a phenomenal, unimaginably brilliant piece of kit and, please note, the emphasis is on *your* brain – we all have more or less the same make and model. Provided you are of this planet, do not have an exotic neurological condition and your name isn't Albert Einstein, there will be very little, if anything, to tell your brain from that of the person next to you.

Yours may be broadly the same make and model, but when it comes to how your own personal brain connections differentiate your individual performance from that of others, there are three very big influencing factors:

1. The environments in which you spend most of your time

2. What you are exposed to in those environments

3. What your time in those environments is actually spent doing

The environments we've spent most of our lives interacting with so far will have slowly but surely shaped our brains. But we humans are very unusual in the sense that we have immense power to shape our environments. We build both the physical environments that we interact with every day and the virtual ones. So we humans are fairly unique in that we can alter the environments that then go on to shape our brains. This means that if we are clever in how we organise our local environments, we can positively influence how our brains are shaped! To encourage

our brains to adapt in a positive way, the challenge for each of us is to try to spend more time in environments that are stimulating and less of it in others.

Yes, our brains are all amazing, but it is how we have made use of them over our lifetime so far that makes each of us unique. More importantly, when it comes to improving performance, it's what we choose to do with them from here on that will determine just how well they continue to serve us in dealing with the daily demands of our own lifestyle.

Flying Start

There are a few things that you could start doing right away to instantly improve your brain's performance and get you off to a flying start. Let's call them Brain Optimisation Principles, or BOPs for short. You can follow these simple suggestions to get your brain firing on all cylinders each and every day. Here are five for starters.

BOP1: Water – Start every day by rehydrating your brain

Believe it or not your brain is 80% water. If you are dehydrated, the speed with which the electrical messages are sent zipping around the 100,000 miles of brain wires is compromised. The trouble is that you wake up slightly dehydrated every single day. How do we know? Well, if you managed to survive until morning then you must have kept on breathing through the whole night. Nonstop breathing is absolutely vital to staying alive because that is the only way to get oxygen into your body to maximise release of the energy that powers all your cells, tissues and organs. It's also the main way to get rid of the primary waste material produced by this metabolic process, namely carbon dioxide. In order to get these gases moving in and out of your bloodstream, the inner surface of the lungs must be kept nice and moist at all times.

This means that every time you exhale, you lose some water vapour in your breath. (That's what fogs up a mirror when you breathe on it – as the warm vapour hits the cool glass, it condenses to become liquid water droplets). During the daytime we replace this lost water whenever we

feel hungry or thirsty and decide to find something to eat or drink. At night there are fewer opportunities, if any, to replace this lost water, so by morning there is inevitably a deficit to correct. So start the day by rehydrating your brain to get rid of that woolly-headed feeling caused by those sluggish, dehydrated neurons.

BOP1: Drink a whole glass of water as soon as you wake up in the morning to quickly replace all the water you lost over the course of the night. And remember to keep topping up throughout the day – for your brain's sake.

BOP2: Exercise – vital for brain health (and for holding onto your marbles)

Exercise is well known to be good for the body, but everyone overlooks its immense impact on the health of your brain. In the short term, the moment you start to do any form of even moderately demanding exercise, your body automatically responds by releasing a torrent of hormones and brain chemicals to make you feel good. Even more importantly, an ever-increasing body of evidence suggests that people who take regular exercise enjoy a better-functioning brain. It even increases the rate at which new brain cells are created in the hippocampus. And it seems to be more important than any other factor in helping people hold onto their marbles well into old age.

BOP2: Do a minimum of 20–30 mins of moderately intensive exercise every day (or 40–60 mins every other day).

BOP3: Stress – Get a grip on cortisol to manage your stress levels

Stress has a bad reputation. We tend to think of it as being a bad thing, something to be avoided if at all possible. Yet cortisol – the primary stress hormone – is vital for helping us to get things done. Released in

your body in response to the problems of everyday life, it actually helps you deal with those problems. It may make you feel "stressed out," but it's most definitely a friend and not a foe.

Cortisol is actually a vital part of any happy, well-balanced and successful life. The part of the equation that many people overlook is that the desire to get rid of that feeling of being "stressed out" is part of the motivation we need to get useful things done. If cortisol didn't make us feel uncomfortable, we'd probably lack the impetus to take action. It also mobilizes body and brain to help deal with life's daily stresses by increasing metabolism, so that more physical and mental energy is available to help us eliminate the *cause* of the problem.

There's a natural daily rhythm to the release of cortisol to ensure that we're keyed up during the daytime and winding down towards bedtime. Bad or upsetting news triggers a boost of cortisol, which is why it's not a great idea to look at emails, social media or newsfeeds in the hour before bedtime.

The key point here is that a little bit of stress in the short term is a good thing but *chronic* stress is most definitely bad. Part of the reason is that in order to help you deal with life's major challenges, cortisol suppresses the immune system. This enables us to postpone feeling ill – which would otherwise force us to rest, to divert all available energy and resources into fighting off the bugs – until the stressful situation has passed by or been resolved.

Chronic stress describes a situation where cortisol levels remain high for many weeks or months, meaning that the body and brain never get the chance to repair properly, nor fight diseases. While it's often impossible to remove the sources of stress in life, there are several things you can do to actively reduce cortisol levels.

***BOP3: Manage stress by proactively setting aside GOM time (see the chapter "All Aboard the Stress Express!"), clinically proven to reduce cortisol levels*.**

BOP4: Get out into nature, go soak up some rays

Getting out into nature makes humans happy. Two or more hours of recreation time outdoors each week makes a measurable difference. In fact, the more time we find to relax in parks, on the coast or in the countryside, the happier we become – an effect that peaks at five hours per week. This is partly due to the calming effect that fresh air and being in nature has on brains, but also thanks to getting more exposure to UV light from the sun.

When ultraviolet (UV) light strikes the skin it makes vitamin D. Vitamin D is vital for bone health, but it is also used in the brain to make a very important brain chemical called serotonin. Serotonin is crucial because it is involved in several brain pathways, including those that regulate mood and sleep. Keeping your vitamin D topped up by getting outdoors on sunny days improves mood by helping to keep serotonin levels high across the whole brain.

> Your skin is your heaviest organ – and weighs three times more than your brain!

In many parts of the world, as the days get shorter there's not enough ultraviolet-B (UVB) light available from the sun to activate production of vitamin D. To keep your serotonin levels topped up year-round, try to be vigilant about getting out into the daylight from spring through to autumn when the UVB is stronger. Don't be put off by cloudy days! While cloud cover cuts out a large proportion of visible light, making it seem a bit gloomy compared to when the sun is out, the strength of the UV light is not diminished to the same degree. This is why you can still get a nasty sunburn on the beach even when it is overcast.

BOP4: Get outside in nature as much as you can. Two to five hours per week makes a significant difference to happiness levels!

BOP5: Caffeine – Great for brains (but morning only is best)

It is estimated that more than 50% of the world's population consumes coffee on a daily basis. That's despite us all having heard at some time or other that too much coffee is bad for our health. So what's the story? The scientific evidence suggests that if you regularly drink coffee then the caffeine *will* make you feel more alert, but only to levels that people who have never touched a drop in their lives enjoy every day! On the other hand, there do seem to be some long-term benefits. Coffee drinkers enjoy a neuroprotective effect in the long run. It seems to slow down the neurodegenerative processes that are responsible for neurological conditions like dementia and Parkinson's disease, by 5–10 years! That said, it's also important to bear in mind that caffeine sticks around in our bodies for a very long time.

It takes *six whole hours* to reduce the caffeine levels in your bloodstream by *half*. That means if you have four cups of coffee in you at midday, then six hours later (at 6 pm) you still have two cups of coffee in you! Six hours after that (at midnight) there will still be one whole cup of coffee's worth of caffeine still in your system! Because sleep is vital for brain health – that's when all the repair and maintenance work, memory consolidation and toxin elimination happens – it's extremely important to get all your coffee drinking done in the morning or it may end up having a negative impact on your brain health overall.

BOP5: Moderate consumption of coffee (3–5 cups/day) protects your brain. But avoid drinking coffee in the afternoon if you want all the brain benefits of a good night's sleep as well!

Old Dogs, New Tricks

Rewiring needed

New skills don't come easy when first attempted but, with a bit of dedication, the early signs of improvement soon become apparent as we start to get into the swing of things. Eventually, what once felt completely alien becomes as easy as a walk in the park.

Why? Because your brain has invested sufficient resources into rewiring the pathways involved in executing that task. The key is not to lose faith when the early improvements start to taper off. Instead, you must keep pressing on. By doing so – and continuing to challenge your brain – it will continue to invest resources into improving communication between brain areas involved in whatever skill you are practising.

For most of us, this is easier said than done. As kids we were constantly confronted with having to try new things on a daily basis and thus struggling with new challenges was a normal, everyday experience. As adults, however, we are drawn by a natural instinct to seek comfort in behaviours that we know we are good at. As a result, we become less inclined to try new things that have the potential to make us feel like a failure. However, those who *do* trust their brains to adapt to any regularly encountered challenge and embrace the opportunity to try new things will inevitably continue to expand and develop their abilities.

As a child you were told by certain people who were most influential to you – parents, older relatives, teachers and peers – that you were good at some things and not so good at others. The themes that you regularly heard not only shaped your beliefs, but also profoundly influenced the environments and tasks that you chose to dedicate time to – the ones you became best adapted to – and the ones you tried to avoid.

If a teacher led you to believe that you were hopeless at maths, then a self-fulfilling prophesy would be born. You would never again greet the prospect of having to do maths with any relish. This shortfall in enthusiasm would result in you not trying. The lack of effort would mean that your brain wouldn't really be stretched and so, as a direct consequence, it would be unable to adapt to improve your abilities. The inevitable poor results that followed would merely confirm your misplaced belief that you are "no good at maths."

The exact opposite also applies, only this time in a self-propelling, upwards direction. If you really believed – because a figure of authority convinced you of your "inherent" talent – that you were good at maths, then of course you would be inspired to do more maths. The consequence of your newfound dedication would mean your brain would be continuously challenged and, as a direct result, would be forced to adapt to do it faster, better and more efficiently each time. With your brain now having invested in some much-needed rewiring, your maths skills would improve, bringing you closer to your *true* potential and, in turn, you'd be even more motivated to do more maths.

You can't teach an old dog new tricks, huh? Well, that may or may not be true, but it's totally irrelevant to us humans. We most definitely can learn new tricks throughout life. We just need to get into the habit of lifelong learning to keep the brain circuitry nice and malleable.

It is true that the brain is *particularly* adaptable during childhood and adolescence. Kids seem to absorb information like sponges, which can make us adults feel as though we have permanently lost our natural capacity to learn new tricks. This is completely untrue. We just don't acquire new skills as rapidly as younger brains do – largely a consequence of how much time we spend each day trying to pick up new skills. Children do it all the time, whereas we grown-ups only do so much, and far less often. Herein lies a crucial difference that explains why, through practice, kids pick things up more quickly than adults: your brain learns to learn during childhood and gets better and better the more learning it does. Unfortunately, most adult brains have fallen out of the habit of learning because of the lack of demand placed on them to attempt new challenges every single day.

Challenge your brain regularly to learn and it will gradually reinvigorate the circuits that make learning happen rapidly. That's all there is to it.

Brain-sharpening work

Before the days of automated production lines, piece workers in pencil factories who had the monotonous task of bundling up pencils and packing them into boxes used to struggle at first to earn a half decent wage. The reason for this was that as "rookie bundlers," being paid by the box, their productivity rate to start with was painfully slow.

(Continued)

The job involved them having to dip one hand into a huge container and depending on required bundle size, pull out an exact number of pencils. New starters would have to count the number of pencils in their hand each time, whereas experienced pencil packers could dip their hand in and instantly pull out an exact quantity. Having done it day in, day out, for long periods of time, their rewired brains had learned exactly what any given number of pencils felt like.

Seeing the astonishing packing speed that could be achieved by seasoned packers and driven by a desperate need to earn good money, novice bundlers' brains were inspired to adapt quickly through trial and error to meet the demands of this dull but potentially financially rewarding skill. Unsurprisingly, thanks to neuroplasticity, their productivity rates soon shot up.

The human brain retains its ability to learn new skills well into the later stages of adulthood. Think about the number of people who, later in life, discovered the art of text messaging and, in a relatively short period of time, became fairly proficient at something that for most of their lives didn't exist. They may never become as quick as young "tech native" texters, most of whom appear to have been born texting, but just think how many older brains have managed to restructure themselves, creating new pathways to embrace a skill that not so long ago was completely alien to them.

A touchscreen nightmare

Shortly after buying my first ever iPhone I seriously began to wonder if I'd made the right choice. I loved the phone but as soon as my fingers went anywhere near its touch screen, they inexplicably felt enormous! In comparison to using my old phone, sending texts and emails took ages.

It's only now since writing this chapter with Jack that I've suddenly realized that I'd totally forgotten about this problem. I'm back up to my old speed and my once super-sized fingers have returned to normal. Brain plasticity in action, yet again.

– Adrian

Talking about new technology, consider a time when a friend or relative from an older generation was introduced to the internet for the first time. They might well have been pretty useless to begin with, but before you knew it they'd worked out how to forward those "funny" email circulars that you probably remember not being particularly amusing the first time round!

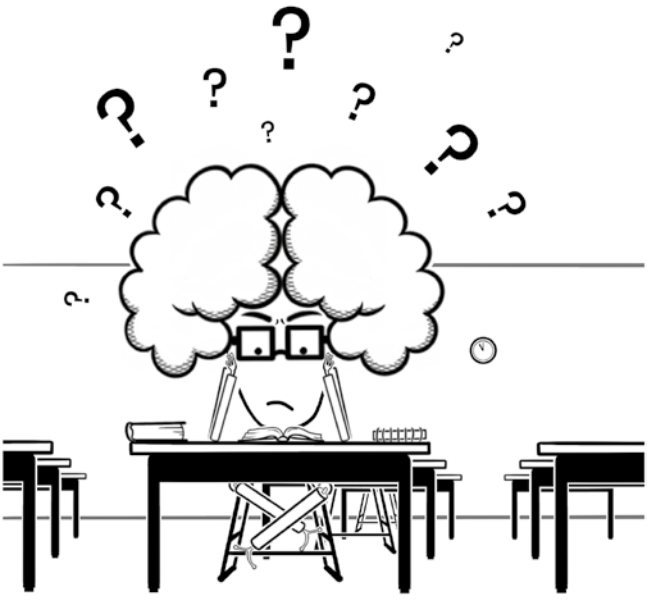
Older people *can* learn new tricks. There's no doubt about that. Convincing older people that this is the case can be tricky sometimes – old habits and stubborn mindsets *can* be tough to shift. But with a bit of self-belief, a regular schedule of practise and a step-by-step approach that helps to focus the mind on a sequence of bite-sized chunks, the only real difference is that older people learn with a slight reduction in speed. And this rate of learning depends largely on how recently they've successfully acquired a new ability, which in turn is powerfully influenced by how motivated a person is to embrace the discomfort of trying new things (that might make them feel stupid) throughout their adult life.

Adults who forever enjoy developing themselves and furthering their talents – whether it be learning a new language, doing some spare time studies, taking up a new sport or pursuing a newfound hobby – usually pick up most skills relatively quickly. That is by comparison with those who, since hitting adulthood, have never really stretched their brains, instead remaining happily cocooned, feet up and slippers on, in their same old comfy routines.

Understanding neuroplasticity inspires the dedication needed to tweak your habits to challenge your brain to expand your range of skills.

The power of imagination

Numerous experiments have been carried out over the years with people practising new skills, varying from shooting basketballs to playing the piano. What's come to light is that – whether or not someone actually physically practises a skill or instead vividly pictures the process of doing it – after only a few days, marked functional changes happen in the brain. Incredibly, changes in those who had only *imagined* practising were almost as significant as those who had practised for real!



That the brain learns to learn throughout childhood is, admittedly, an odd concept to get your head around. As well as having to learn the very basics such as walking and talking in our first couple of years there was just so much to learn before we even got anywhere near stepping

through the school gates – at which point intense learning became the "normal" state of affairs, both in the playground and the classroom, as we were regularly confronted with and tested by situations that took us out of our comfort zone. This happened not just in lessons, but also outside of formal learning times, as we navigated the twists and turns of learning how to get on with other people in all aspects of life. It could have been when practising sports skills, trying to work out the unfathomable rules of attraction or negotiating our way through daily social exchanges with family, friends, strangers and those regarded as arch enemies. Feeling out of your depth at that stage in life might not be particularly pleasant, but it's nonetheless a familiar, if not daily, occurrence. And it's relatively easy to deal with when everybody else is in the same boat.

In adulthood, however, we have more freedom of choice and can exert much more free will over what we will and will not spend our time doing. Not surprisingly this means that we tend to gravitate towards activities that we are good at, enjoy doing or at least remain squarely within our comfort zone; "set-pieces" that through repetition have become so well known to our brains that we barely register how we're doing whatever we're doing.

Unfortunately, this means we become more and more unfamiliar with the feeling of struggling to grasp a new idea or skill. Out of practice in dealing with such feelings, we either don't engage with it fully or try to dodge it entirely. It's human nature to be drawn towards activities that increase our sense of well-being and to be repelled by those that decrease it. Alas, in doing this, we inevitably turn ourselves into set-piece specialists. In fact, most people spend their entire adult lives doing things they have done many times before *because* those activities can be done with the least amount of cognitive effort and the smallest possibility of generating feelings of inadequacy.

We like to operate on autopilot because it's less hassle, less stressful and tends to reduce anxiety. The problem is that the easiest route in the short term is rarely the best path in the long run. And if there's one weakness that we humans often fall foul of, it's our tendency to choose the immediate, easy reward and worry about any long-term drawbacks later (or better still, never).

Sign here

See if you can do something that you've done many times before, probably without thinking about it, but this time do it slightly differently.

Try signing your name really slowly.

Difficult, isn't it!? That's a motor "set-piece" right there – an automatic action made inaccurate by too much thought.

Bring it on!

Throughout most of human history, becoming a set-piece specialist was absolutely fine. You spent childhood learning the basics, adolescence becoming a cog in some machine or another and adulthood winding that cog via a repertoire of set-pieces in a job for life, putting food on the table to feed hungry mouths who themselves would, in turn, go through more or less the same life transitions.

The world, however, has changed since those days. The world has always been changing but, as we humans have become more and more adept at controlling and manipulating the environment around us, that rate of change has steadily accelerated. This has certainly been the case since the Industrial Revolution, when machines started getting involved. The changes used to only really be noticeable from one generation to the next. Then, during the 20th century – when great technological leaps impacting daily life started happening more regularly – they became readily apparent from one decade to the next.

Now, in the 21st century, everything has gone and sped up again! New innovations are continually impacting on the way we work, how we socialize, how we raise children, what we do for entertainment and how we think – fast, continuous, unprecedented change that is influencing

every aspect of our lives. This increases the environmental pressure on our brains to adapt and keep up with the breakneck pace.

But fear not, your brain is more than up to all this. If there's one thing above all others that is *most* impressive about your brain, it's the degree to which it can change to adapt to all the new challenges that will inevitably crop up. This is exactly the feature that made us humans the most dominant species on the planet in the first place.

We are *incredibly* adaptable. Our brains will gradually change to serve us better in any given environment. Our collective ingenuity has led to the development of a variety of tools with which we can sculpt our environment. By creating new environments and carefully choosing which environments we immerse ourselves in on a regular basis, we can in fact change our own brains. It may sound miraculous. It is!

Rising IQs

IQ stands for Intelligence Quotient and is the world's most popular and well-known intelligence test. Up until the end of the 20th century the broadly held assumption was that once a person hit adulthood their IQ score would remain stable for the rest of their life. Then along came an ingenious Kiwi psychologist by the name of James Flynn, who noticed something curious. When he compared IQ scores of the same people, from one IQ test to the next taken a few years later, they'd gone up. We now know that IQ scores around the world have increased by an average of three IQ points every ten years!

What is driving this increase in intelligence? As far as we can tell it is driven by an increase in consumption of information and the extensive use of a steady flow of new technologies. From decade to decade the amount of information we have access to has dramatically increased, first via television and then through the internet. The more information our brains have to juggle on a daily basis, it seems, the higher our IQs go!

Finding flow

To get the best performance out of your brain, you should bear in mind what modern neuroscience has taught us are the rules of the game. Your brain will physically rewire the connections between brain areas involved in any regularly used mental ability so that the interactions between them are:

- Faster
- Stronger
- More efficient

To improve your skill you must take care to perform the desired mental function:

- Regularly (ideally daily)
- Intensively (tackle challenges that stretch your abilities)
- Over long periods of time (keep up the training over many weeks)

This essentially describes what is popularly described these days as "brain training." It might sound terribly impressive and you might even have been misled into thinking that you need some special kit to do it properly, but that really isn't strictly necessary.

With a whole bunch of useful brain teasers in an easily portable package, brain training applications on various devices *could* make brain training more convenient. This convenience might even improve your devotion to self-improvement. Market-leading companies may well have millions of subscribers for their particular games, but popularity doesn't guarantee effectiveness. Just remember that you are training your brain whenever you engage in anything that taxes your grey matter regularly, intensively and over long periods of time.

Working memory

Working memory is what you use to keep a phone number in your head for long enough to dial the number. You also use it any time you plan what you're going to do with your day or try to solve a problem. Sights, sounds and any other relevant pieces of information can be held in mind on the "Hold Line" (see Outward-Facing Brain Tube map in the Appendix) for just long enough to perform a mental task effectively.

Experiments investigating brain training have found that certain exercises increase working memory capacity (e.g. the "Dual N-Back" training task) and being able to simultaneously hold *more* information in mind supports many other useful cognitive capabilities. In fact, if we can improve our working memory, our IQ score will increase thanks to its positive impact on "fluid" intelligence.

As you improve at any skill, hobby or mental ability you are engaging in brain training. There is no evidence so far to suggest some kind of magic ingredient in the commercially available games – just convenience. The convenience might make a difference in helping you to keep going for long and hard enough to have a tangible impact in how your brain functions, in those games, at least. Sadly, any hard evidence that improvements in the games can translate into benefits in everyday life is suspiciously minimal. To gain the full benefits of "brain training" you'd probably be better off taking up a few new hobbies instead.

The key to doing enough mental work to actually make a physical difference to how your brain functions is finding "Flow." Flow is a psychological phenomenon made famous by Mihaly Csikszentmihalyi (pronounced "six-cent-mihal-i) with a specific meaning that has been bandied around so much it has lost most of its original simplicity.

The average capacity of working memory is seven items. By regularly practising to hold more items of information than that in your mind (e.g. phone numbers, shopping lists or credit card numbers) for long enough to do something useful with them, you can increase your working memory. That in turn leads to improvements in your problem-solving abilities.

To remember what Flow is all about, just think about Goldilocks. She wanted her porridge to be "not too hot, not too cold, but just right." Flow comes when you challenge your brain with some kind of absorbing mental task that is "not too hard, not too easy, but just right" – it keeps you keen to keep on going and creates a state of mind where time just seems to fly by.

If it's too easy for you, keeping your head down for a solid half an hour might be no problem, but your brain will only invest resources in changing its connectivity if it is pushed out of its comfort zone. If, on the other hand, the challenge is too hard, you might end up feeling stupid, convincing yourself that you're getting nowhere and that the task is futile. That's no good because you'll only end up feeling all frustrated, wound up and looking for something less productive to do instead.

This, incidentally, is something that some of the new brain training games tend to be very good at – successful computer game designers are masters of finding this sweet spot: where the gaming experience is challenging but without leading to despair. At the same time, they are also extremely adept at getting people addicted to their products, so bear that in mind too!

Whatever brain training you do choose to do, whether it's getting to grips with a new software package, memorizing some useful numbers or perhaps learning how to cook a new dish – it will change your brain most efficiently if you manage to find Flow. This is because Flow keeps you at it for long enough to trigger brain changes. Having found Flow

you'll no doubt have also experienced enjoyment from the process and taken away some real satisfaction from your achievements, so you'll likely be greeting the prospect of doing it again with enthusiasm rather than dread. Finding Flow in the next challenge will be key to ensuring that your self-propelling belief keeps you going in the right direction and that your brain continues to invest in whatever rewiring is required.

You can't do that!

At the age of 43, I published my first book – Polar Bear Pirates and Their Quest to Reach Fat City. *Despite the fact that I had been told on more than one occasion that I would never be capable of writing a book, it became an international bestseller.*

– Adrian

Chapter takeaways

- By doing brain training that improves your working memory – as far as your IQ is concerned – the only way is up.
- If you want to make progress in developing new skills, you'll first need to learn to learn again. Do a little bit *every day* and you'll soon feel comfortable being out of your comfort zone, just like you did as a child.
- To discover the positive effects of neuroplasticity and continue to improve at something, you need to do it regularly, intensively and over long periods. That's all "brain training" really is!
- Step beyond set-pieces. Stretch yourself. The easiest route in the short term is rarely the best path in the long run.

- Remember the Goldilocks Rule as applied to "Flow" – set yourself goals that are not too easy, not too hard, but just right!

- Yes, you can teach an old dog new tricks.

Cyber Heads

Brain for sale – no longer needed

Is technology good or bad for our brains? With around 4.5 billion active internet users, 41 million text-based messages sent every minute and many people now spending more time gaming online than they do sleeping, are we all becoming mindless zombies, unable to interact with each other on a face-to-face basis? Or are people getting all worked up about nothing, worrying unnecessarily about the potential consequences of digital immersion that, in reality, pose no major threat to the future of the human race?

> The more Facebook friends a person has, the greater the grey matter density in brain areas involved in social interaction.

The truth is it all depends on what type of technology you're talking about. It also depends on how intensively the technology in question is being used. And it depends on the specific person using the technology. As with most things the rule of thumb is this: Everything in moderation.

The main threat of many technologies is that many games and applications are often *specifically designed* to encourage overuse. The twin problems associated with using a certain technology for many hours every day are: 1) you will probably be diverting time away from other activities that would yield greater benefit for your productivity and well-being

and 2) you could well be triggering neuroplasticity that leaves your brain *worse* at meeting many of the challenges of everyday life rather than *better*.

Internet search engines make a whole world of information instantly available to us, literally putting the information at our fingertips. So why would anyone want to bother committing anything to memory when it can be pulled up on a screen within seconds? Recent studies have shown that this might not be a great idea.

When people know they can just search for the information again in the future, they retain what they've learned only for very short periods of time. It turns out that they're pretty good at knowing where to look to find this information again in the future. But until they do that, the information tends not to be available in their memory, posing a problem when it comes to getting wiser. No wonder conversations are forever being put on pause while people fiddle with their smartphones – to find those facts that they know, but can't quite remember.

Access: In 1984, there were one thousand devices hooked up to the internet across the globe. Eight years later, in 1992, this number hit the one million mark. The one billion mark was crossed in 2008. These days it makes more sense to count how many people in the world *don't* have some kind of access to the internet (fewer than 2 billion in 2020).

Quantity: By 2020 the digital world had been estimated to comprise 44 zettabytes (forty-four thousand, billion, billion bytes). That's more bytes of data on the internet than there are stars in the *universe*.

Labour-saving devices have unquestionably changed our lives beyond all recognition, but will the continuing tsunami of innovations leave us all with redundant brains, unable to do much without technological assistance? As yet, there are no conclusive answers to such questions.

But you can rest assured that your brain will have been doing what brains do so brilliantly well – changing and adapting to meet the demands of the new digital environment it now spends the majority of the waking day immersed in. No matter how old your brain happens to be, it will already have been busy reconfiguring and shaping up to embrace whatever new challenges this ever-expanding techno era happens to throw at it.

I want it now!

Our brains might have changed over the years we've been alive, but human nature – as determined by our DNA – has not. The main reason why we, out of approximately 8.7 million other species currently sharing this planet, have been so successful is largely down to a deep-rooted desire to feel a sense of progress. Thanks to lightning-speed technology, we are now all advancing at an ever-increasing rate with everybody expecting everything to be done in an instant – we want it now! And if we don't get what we want fast enough, human nature is such that we'll always be on the lookout for a shortcut. As soon as one becomes available, we'll take it!

With shortcuts at the very heart of human nature we are all, unsurprisingly, more than happy to take the quickest option that modern technology can provide. And with the prospect of life improvement being at the forefront of our minds, at the earliest opportunity most of us will interface with whatever the latest technology happens to be, in the belief that it's going to make life easier or more interesting. This is an assumption that many people end up regretting.

We may always be looking for the fastest, easiest route forward, using a whole array of "external brain" devices at our disposal, ranging from laptops to smartphones. We may have found numerous new ways of shifting a lot of the workload to them. But that doesn't necessarily mean that our brains are going to have less to do. Nor does it mean that they are going to become lazier and inevitably, having become semi-dormant, find themselves out of a job.

On the contrary, a lot of the groundwork might be done for us, but by shifting it we simply free up cognitive resources for a new pile of (often unnecessary) extra work, along with a whole new set of pressures and obstacles created by it. All of which will need to be overcome and dealt with at an ever-increasing rate.

When calculators first came onto the scene there were serious concerns that they would make minds stagnant by taking away the need for mental arithmetic. More recently, when internet search engines first appeared, there was much talk about them making brains intellectually lazy. In both instances, very little evidence accumulated to back up these concerns. Instead it seems that both innovations mostly unlocked new possibilities and, brains being brains, they have moved onto bigger, more exciting challenges.

Despite how much new technology arrives on the scene, if we fully utilize it in a way that finds balance with the non-technologically enhanced aspects of life, our brains should be moving in the opposite direction to idleness. Having once been stretched to the limit by performing a

particular function, they should find themselves having to grapple with completely different tests in new areas.

For example, where a brain was once challenged by the prospect of map reading, advancements in technology will mean that, despite no longer having to be quite so proficient in that skill, it will have to rise to the challenges of operating and following the instructions of satnav, but while still using your loaf. Those of us who have experienced setting off from A to go to B only to end up in C will know that this is no mean feat. Despite thousands of years' worth of inherited instinct and our gut feelings screaming at us that we are heading in completely the wrong direction, we still keep faith with the technology. It's important to be master, not slave, to our technologies; *you* still need to be the boss.

"The greatest task before civilisation at present is to make machines what they ought to be, the slaves instead of the masters of men."
Havelock Ellis

Forever lost

Your satnav doesn't have common sense – you do. Map reading and navigation are useful skills to have, particularly in the event of a technical hiccup. If you want to hold onto them, maintaining your self-navigational skills is simple. Don't rely on satnav all the time, especially when you want to get to places you've been to many times before.

Think of all those drivers of London's black cabs whose inflated hippocampi shrink back down after they retire. You need to keep on reusing those navigation pathways of your brain to keep them fresh. Before switching on the satnav, take a look at your route on a map to give yourself an idea of where you're going.

(Continued)

The cognitive gymnastics required to convert a 2D map into a mental picture of the route you'll be taking in the 3D world gives parietal brain areas involved in "mental rotation" a great workout. And hopefully, the next time you find yourself driving the wrong way down a one-way street, in the middle of a building site or along a road that doesn't exist, common sense will prevail.

The bottom line is that whether or not a brain does get made redundant is of course up to its owner. Neither technology nor the brain itself can be blamed if, through lack of appropriate stimulation, certain parts get left behind. Provided you give your basic cognitive abilities regular chances to be stretched, your brain is more than capable of keeping up.

External brain reliance

As far as brain health is concerned, making use of technology is not in itself a problem. What is currently causing alarm in some circles is the increasing number of people who are becoming permanently hooked into and addictively dependent upon, certain types of technology.

Even the less observant will have noticed the blind reliance that more and more people are placing in their devices. Taking a few moments to reflect upon the behaviours of people you see each day will surely convince you that an obsession with gadgetry is taking over people's lives. Walk down any busy street in any town and it won't be long before you see someone scurrying along the pavement, head down, squinting at some device or other – only to step out into the road without looking.

With minds elsewhere, these digital lemmings seem completely oblivious at times as to just how close they are to eradicating themselves from the human gene pool. Perhaps their need to be permanently technologically engaged drowns out their awareness of everything else around them or maybe an overestimation of their own ability to multitask is leading to more subtle cognitive drawbacks than being hit by a bus.

Whatever the reason, many people are becoming too dependent on their smartphones for their own good. One of the classic measures of overdependence is automated, unthinking behaviour. How often have you seen people in your midst failing to resist the temptation to pull out their phone the moment they hear it beep, buzz, ring or feel it vibrate? Have you noticed that this often happens regardless of whether or not the circumstances make it appropriate to do so? The most popular times seem to be during meetings, in restaurants or while attempting tricky driving manoeuvres.

Should such unsociable, at times rude and potentially dangerous tech habits be tolerated on the basis that "you can't stop progress?" There is no definitive answer to this; it is down to each and every one of us to decide for ourselves. One thing, however, is becoming apparent, whether it is you, family members, friends, colleagues or complete strangers that you've witnessed doing this – it's a fairly safe bet to make that you are now so familiar with these scenarios that you're beginning to accept them as the norm.

On a related topic, "cybermigration" describes a phenomenon where certain new behaviours slowly become acceptable online and then, before you know it, those same types of behaviour suddenly become tolerated in the real world too. When this kind of thing happens, people can unwittingly find themselves affected by cultural changes driven through technology, even if they don't use it themselves!

Social cooling effect

Tech natives who spent most of their adolescence in a world where more or less everyone owned a smartphone may have become more self-conscious than previous generations. Teens used to be notorious for acting out, taking risks to show off to their friends or play the fool. Now that everybody has a camera on them and in seconds the photos they take can end up on the internet forever, young people have become more wary about taking the chance of getting snapped doing something stupid.

Will technology ruin our brains?

To date, most of the available evidence on whether digital technology is good or bad for your brain is still in its early stages and is a bit of a mixed bag. Studies are being conducted at this very moment in an attempt to provide hard data to establish whether our obsessive use of gadgets is having unintended negative consequences. The trouble is that, with lightning-fast changes in technology, it's a bit of a moving target. Trying to study the impact of any given type of technology is hampered by the fact that it often changes dramatically from one year to the next, as does how people actually use it. This makes it very difficult to work out exactly what *causes* the various changes in behaviour and brain structure. That said, a few studies have already hit the academic press from which we can start to forecast the likely future findings.

The truth is, technology in and of itself is neither good nor bad. The problems generally arise when people overuse it. Your malleable brain, as you are now more than aware, will accommodate the demands of any environment, whether it is physical or virtual in nature. The ongoing adjustments to the demands of the digital environment happen, for better or for worse, whether you like it or not, for as long as you continue to engage regularly, intensively and consistently with any given technology.

In addition to this, as we know, old habits – once formed through repetition – die hard. For instance, eating habits adopted in childhood (when metabolism is relatively high) almost always continue into adulthood (when metabolism inevitably slows down). In the absence of regular intensive exercise to burn through it, the consequent excess of calories leads to an expanding waistline – a scenario familiar to all but the most disciplined of eaters.

The same principle can be applied to technology. Once a person develops a reliance on technology, including an expectation of regular messages and online updates, any interruption to the flow of communication can lead to panic. They might find themselves throwing a hissy fit when unable to get a connection or, worse still, fall into a spiral of depression

when a whole day passes by without hearing the reassuring ping of messages or seeing likes on their social media posts.

Smartphones: the adult pacifier

Many people effectively use their smartphone as a "comforter." Just as a crying baby can be calmed down when given a dummy (aka pacifier) to suck on, many adults these days gain a similar comfort from picking up their smartphones. The trouble with this is that recent research suggests that the more people look at their phones each day, the less self-insight they have. Personal realizations and breakthroughs in interpersonal problems usually follow periods of intense internal debate. But these internal debates simply don't happen very often if a person is constantly looking at their smartphone whenever they're alone.

Staying in to play

With some people spending up to two months per year glued to it, a big concern for a long time was the amount of time people spent watching television. With the average household now having more screens in it than people, the latest worry is over the amount of time being devoted to computer games. With so many spending huge chunks of their lives participating, a major concern with video gaming has been that the violent nature of many titles might be leading to a new generation of morally corrupt individuals. It turns out that there is little evidence to support this.

In the case of both excessive TV watching and video game playing, the main problems revolve around displacement of time that could have been spent doing something more useful, such as socialising with friends face-to-face, rather than connected by microphones and headphones to enable fluid team coordination in the latest gaming craze to hit the "massively multiplayer online game" world.

A huge amount of valuable information is lost in any form of communication that doesn't do a good job of conveying a person's facial expressions and body language. This is this case when socialising through videoconferencing apps and video games, but also it also happens when socialising in person under circumstances where everyone spends most of the time looking down at screens instead of at each other's faces. Because body language is the raw material our brain circuits use to help us understand the emotions that other people are experiencing – circuitry that enables us to empathise with others – the concern is that these brain areas might not develop very well in the first place or might struggle to maintain these important interpersonal skills according to the principle of "use it or lose it."

It's not all bad, though. There are actually several brain benefits to be had when gaming enthusiasts clock up many hours playing "first-person" action video games (where you see through the eyes of a character as you shoot anything that moves). Brains adapt to the perceptual and cognitive demands of such virtual worlds, leading to unexpected, positive enhancements in several areas. Superior visual perception, visual short-term memory, spatial cognition, mental rotation, multitasking and rapid decision-making improvements have all been demonstrated, compared to an equivalent amount of video game play that *doesn't* involve running around shooting at fast-moving objects.

The trouble with the youth of today

When driving in my car I often stop just down the road from where I live to let a group of teenagers coming home from school cross the road. Every time I do this, I get the distinct feeling that both my car and myself are invisible. I don't think in the past two years any of them have ever put their hand up in acknowledgement of me stopping for them or even given me so much as a nod of recognition that I exist. This worries me.

It could be that they simply lack the confidence to engage with others outside their group, particularly an adult. Maybe they just don't have the social skills to do it or perhaps common courtesy isn't particularly high up on their agenda. They appear to be so wrapped up in their own worlds that they are oblivious to everything around them. I've often thought that the possible cause of this disconnected, insular behaviour could be technology. It would be easy for me to attribute it to them being tech natives and assume their preferred mode of communication must be via email or text.

I could put it all down to technology, but then I'm always reminded of this:

"Our youths love luxury. They have bad manners, contempt for authority – they show disrespect for their elders and love to chatter in place of exercise. Children are now tyrants, not the servants of their households. They no longer rise when their elders enter the room. They contradict their parents, chatter before company, gobble up food and tyrannize teachers."

It's a quote attributed to Socrates, the famous Greek philosopher who lived from 469 BCE to 399 BCE. It would seem that in two and a half thousand years, technology or no technology, some things just haven't changed!

– Adrian

The concerns of parents worrying that too much time spent staring at screens might ruin their kids' eyesight, on the other hand, may have been well placed. The rates of short-sightedness, particularly in China, have rocketed over the past few decades in a manner that parallels an increasing preoccupation with screens.

That said, certain types of therapeutic video gaming are now prescribed to help people improve visual problems associated with conditions like amblyopia (aka lazy eye) and others that help middle-aged people strengthen their eye muscles to postpone the need for reading glasses

by a few years. Technology seems to forever give with one hand and take away with the other!

Another aspect of time-displacement worth mentioning is that unless you're managing to exercise at the same time (very possible with virtual reality, but highly unlikely with conventional video games), spending endless hours in front of a screen, whether a TV, PC, laptop, tablet, games console or phone screen, isn't going to do anyone any favours in the physical health department. Excessive amounts of screen use has been directly blamed for the current global obesity pandemic, increasing rates of cardiovascular disease and Type 2 diabetes.

Fatal attraction

In 2005, a South Korean man named as Lee Seung Seopp dropped dead of heart failure after playing a game called *StarCraft* for over 50 hours straight. His obsessive game play displaced precious time that he could have spent ensuring that he ate and drank enough to stay alive.

In 2007, a Chinese man named Zhang died suddenly after playing *World of Warcraft* continuously for seven days.

In 2009, back in South Korea, a 41-year-old man and a 27-year-old woman became so obsessed with an online role-playing game involving caring for a virtual infant that, in a horribly ironic twist, they accidentally starved their own real-life, three-month-old baby girl to death.

You might be forgiven for thinking that this problem is specific to East Asia, but that isn't the case. Digital innovations have historically been made available (and embraced) earlier in these countries, before much of the rest of the world got their hands on them. Observing the negative outcomes of digital over-immersion among these early adopters gives the rest of the world a valuable

heads up, helping them to take preventative measures to avoid repeating such unfortunate and lethal scenarios.

In May 2019, gaming addiction was officially classified as a disease by the World Health Organisation and six months later the UK's National Health Service inaugurated its first National Centre for Gaming Disorders.

Multitasking?

Not that long ago it was rare for people to watch TV while simultaneously surfing the internet. Now such "dual-screening" is commonplace. Studies investigating this behaviour revealed that people switch their attention between screens on average about 120 times during a 30-minute viewing period. That's about four times per minute or once every 15 seconds! Could this herald a brave new era of prolific multitasking, enabling us to squeeze *yet more* efficiency out of our busy, information overloaded lives?

The first thing to get to grips with is that there is no such thing as true multitasking. Yes, we can walk down the street while talking on the phone, but that's partly because our walking expertise is so innate that we can do it entirely without thinking and partly because it's governed by its own dedicated brain resources. But our brains haven't yet evolved the capacity to simultaneously perform two completely different tasks that require the *same* cognitive resources. The truth is that most mental tasks that *feel* like they are being done in parallel actually involve rapid switching between the two. And, anytime a human brain switches from one task to another, there is an associated cost. You don't pick up where you left off straight away when your mind returns to the "other" task. There is always a slight delay – known as a "switch cost" – in remembering exactly where you were so you can continue with the original task.

While women may be famous for their multitasking skills, the idea that all those tasks are actually happening in parallel is an illusion. Women who *seem* to have a superior ability in this regard, compared to most men, are usually better at *minimizing* the inevitable switch cost. While some people, through regular, intense and consistent training, have become extremely adept at making this process as efficient as possible, there is nonetheless always a small, unavoidable time penalty associated with each switch between tasks. In men the switch cost tends to be larger than in women, but there is always a measurable negative consequence of switching between multiple cognitive tasks in both, as compared to simply focusing on one task at a time.

The buzz and bleep of modern living

Smartphones are a constant source of unintended distraction, which can derail your productivity no end. "Unintended" is the critical word here because "intended" distractions are ideal for shifting gear into a different brain state. Creative thinking can really benefit from a bit of well-timed distraction, especially when a person's brain is cluttered with anxious thoughts and stuck in rigid ruts, while tussling with seemingly

unsolvable problems. Intentional distractions – those that happen at a time of our choosing – can help you to refocus the cognitive machinery and let the ideas flow more freely.

The problem with unintended distractions, like those caused by smartphone alerts notifying you about every text message, email, call or social networking update, is that your attention is repeatedly pulled away from your thought processes. Each time that happens you are robbed of the opportunity to see your train of thought through to its natural conclusion. If you allow tech to constantly interrupt your thought processes, all those distractions add up to a large bill of switch costs, many missed Eureka moments and an unproductive day at the office.

But don't our ever-changing brains constantly adapt to help us perform better in any given environment? Surely brain pathways will be reconfigured to help us block out these minor distractions? To a certain degree, yes, this is possible – but in the absence of a tailored, intensive, training regime aimed at achieving this specific end result, it's extremely unlikely to happen by chance. It makes much more sense to switch your devices to silent, whenever possible, so that *you* can choose when you interrupt your flow to check for messages and missed calls.

Instant response pressure

The virtual world of social and professional networking is cunningly designed to lure us into patterns of use that get us addicted to constant interaction. This is generating a whole new, previously unknown world of stress. Teenagers and adults alike are often expected to reply immediately to any text, email, instant message or online social networking message. Teenagers who don't respond straight away risk being socially ostracised and adults face the possibility of losing out at work or in new business opportunities. Many people now feel a huge pressure to be available constantly, day and night, throughout the weekend and even on holiday.

(Continued)

It makes sense to do whatever we can to better manage the expectation of an immediate response to create a stress-relieving buffer between ourselves and the cyber-onslaught of constant connectivity. To have any hope of changing other people's expectations you need to set up a voicemail message or automatic email reply along the lines of: "Thanks for getting in touch. To improve work flow I pick up calls and emails just once or twice a day. I will endeavour to get back to you within the next 24 hours. Thank you for your patience." The idea is that by giving them an accurate idea of when they might hear back from you, they know what to expect and realise that you're not going to be instantly available.

We can't change a culture of high expectations overnight, but little by little, starting with friends or family and then moving onto professional contacts, once everyone realizes just how important this is, we could eventually regain the right to reply at a time that is right for us.

Brain training ourselves to distraction?

One early study found that people who regularly used different types of technology all at the same time (heavy media multitaskers) were less able to block out distractions in a simple visual task than those tended to only use one form of media at a time (low media multitaskers). The performance of the heavy media multitaskers declined more and more when extra distractors were added around the targets, while that of the low media multitaskers remained steady no matter how many distractors were added. In other words, the low media multitaskers had retained their ability to ignore the distractors but the heavy multitaskers seem to have lost this basic ability.

A likely explanation for this is that their daily, intensive, long-term media multitasking habits may have led to brain changes that made them more easily distracted. They may have unwittingly trained their brain

to constantly refocus on any extra information in the scene, regardless of its relevance to the task at hand. The only way to prove that these behaviours actually *cause* increased sensitivity to distraction would be to compare measurements before and after people started engaging in heavy multitasking. The trouble is such people are almost impossible to find. In the meantime, you might want to think twice the next time you start checking your phone, while watching the news on TV, during a videoconference attended via your laptop.

> Heavy media multitaskers are generally worse at controlling their impulses and score lower in tests of fluid intelligence than low media multitaskers.

One thing that should be becoming crystal clear by now is the need to stop and think. In using all the wonderful tools of digital technology, how much is too much if we want to avoid sleepwalking into a nightmare of attention problems and undernourished empathy circuits? We need to dream up ways to gain all the benefits, but without falling into the trap of accidentally adopting habits that actually work against our best interests. Trying to establish our own personal set of rules governing how we actually use each type of technology is a good place to start. For instance, next time you get a new phone, actually read the instruction manual, or the help webpages. Not the whole thing, just the part that guides you through the process of changing which alerts can make it buzz and bleep and which silently register the messages without causing endless "unintentional" distractions. The best approach is to switch off any alerts that are not likely to be time critical and stick the whole thing in a drawer out of sight as much as possible.

Ask yourself: do your text messages really require instant attention? Do you really have to be alerted to every single email that lands in your inbox the second it arrives? Is the news that a random stranger is now following you on Twitter, Instagram or TikTok urgent enough to risk halting a fascinating conversation, to steal precious time spent with family

and friends, to derail a productive flow of thought, crash a car or walk out into the road without looking? Or can these relatively low-priority interruptions wait until later?

Digital addiction litmus test

How often do you feel the need to pull your phone out and check it for messages?

Having given yourself an honest answer, try this: switch your phone to silent and hide it away somewhere for 60 minutes at a time for just one day. Only allow yourself to have a look once an hour – no peeking!

Humankind has managed to get by for thousands of years without handheld communication devices and yet research suggests that on average we check our smartphones every six and a half minutes.

Over the next five days, keep a tally of how often you *do* find yourself picking up your phone and checking it. You might be surprised about just how addicted you've become. Surely once every hour or two is enough to stay on top of everything – isn't it?

Chapter takeaways

- No matter how much the world changes, your brain will already have been hard at work physically tweaking its circuits to make everything in its regular environment seem like the new normal.

- By shifting your workload to "external brains," the pace will quicken and new challenges will emerge – but beware of becoming overreliant.

- Don't go blaming technology for the behaviour of teenagers. Remember, they've been around a lot longer than technology has!

- Brains don't do multitasking; they do task-switching, which comes at a cost.

- Are you the master or slave of your digital devices? Make sure you're the one calling the shots or else your brain will adapt in ways that serve you badly; don't lose your focus.

- Unintended distractions add up. What's the sum total of yours so far today? How many *Eureka* moments did you miss due to avoidable disturbances to your train of thought? Put it on silent!

Gone Fishing (for Great Ideas)

Dunking

When trying to come up with new ideas, there's something you can try out that we call "dunking." As well as being wonderfully relaxing, dunking can be a very effective way of being more innovative. It's a technique inspired by the brilliant engineer Thomas Edison, whose inventions truly changed the world.

He would sit in a comfy chair with his arms hanging over the sides while clutching two large ball bearings, one in each hand. Each was strategically placed, dangling over a bare patch of wooden floor, so that the moment he drifted off to sleep his hands would lose their grip on the ball bearings, which would then clatter to the ground, waking him up with a jolt. By dunking in and out of sleep like this he found he could take advantage of what is known as the "hypnagogic state" – the no-man's land between wakefulness and sleep – when the brain is most likely to have its best ideas.

Just like dunking biscuits into a hot cuppa, the secret is not to stay dunked too long. Otherwise you drop off completely into deep sleep, which would mean losing any great ideas that might have bubbled up from the depths of your unconscious mind. You might well have already noticed that your best ideas come to you when you're daydreaming in the bath, on the loo or commuting by bus or train to and from work. These scenarios provide great opportunities for cracking difficult problems because, in each instance, you might just doze a little without completely drifting off. If you fell completely asleep your hippocampus would be wiped clean, leaving you with no memory of your great ideas, but

fortunately in these places you need to be a bit vigilant to deal with the associated dangers: like drowning, falling off the toilet or finding yourself drooling on the shoulder of the adjacent passenger.

The other daily opportunity to do some dunking in the privacy of your own home is during that most precious "snooze time" in the mornings, after your alarm has gone off but before you actually manage to drag yourself out of bed. You're half awake, still in that cozy, lethargic state and desperately trying to make the most of those all-too-brief minutes before it goes off again. This particular no-man's land – that you emerge into after a night's sleep – is called the *hypnopompic* state and is also an extremely fertile brain terrain from which great ideas can grow.

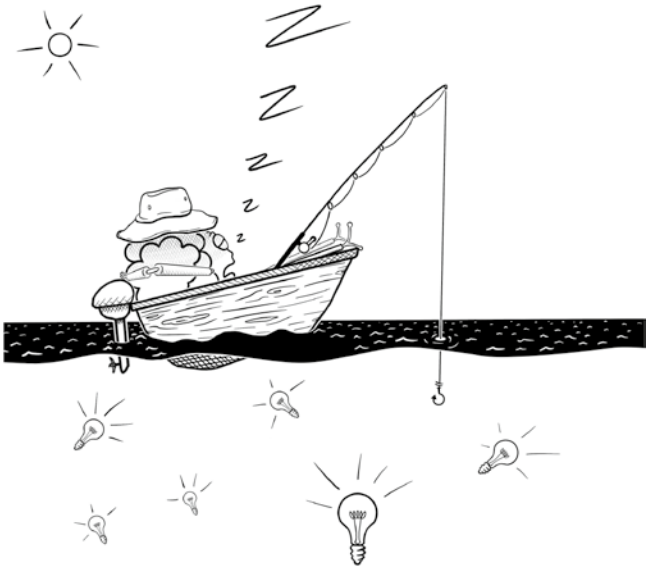
Try to use this time for a quick dunk by pointing your relaxed, wandering mind in the direction of whatever you were working on the day before. Your brain will have been hard at work overnight, trying to connect the dots and tie up loose ends from the previous day, so you may be able to nab some of the inspirational ideas still flitting around in your head from the end of your last sleep cycle (more on this later). Make sure you jot these ideas down on a notepad – strategically left on your bedside table for exactly this purpose – before the more mundane and less useful thoughts can pop into your head. For many people this will require that you put your phone out of reach when you hit the sack, so that you can't look at it the very moment you wake up and thereby swat away all those fledgling hypnopompic breakthroughs.

Why is dunking so effective?

Although right now you may be completely oblivious to it, your brain is constantly working away beneath the surface of awareness – the "subconscious" processing that is forever posing questions, solving problems, triggering memories and looking for connections between freewheeling thoughts. Dunking enables you to briefly dip below the surface, by turning down the volume on the outside sensory information, to capitalize on all this unseen hard work.

"Consciousness" is all the stuff you are aware of: the sights you see, the sounds you hear, the thoughts you think and that voice inside your head that narrates the moment-to-moment events of your day. The "subconscious" is all the work that your brain does – the vast majority, in fact – that you have no awareness of.

The reason that so much of what our brain does goes under the radar is that consciousness has a limited capacity, while that of the subconscious is much, much, much larger. If your conscious awareness got tangled up with every last little detail that your brain processes in any given second, your mind would be in a permanent state of chaos. Conscious thought is spared from being drowned in all that information to ensure it has sufficient resources to prioritise the most pressing matters. Conscious thought is just the tip of the iceberg in terms of what your brain is up to every moment of every day and a sneaky peak at the bubbles rising up from the deep, breaking at the surface, can be extremely rewarding.



Even when you are feeling totally uninspired, your brain is nonetheless always busy dealing with a constant, never-ending onslaught of information. Sights, sounds, smells, bodily sensations, unbidden memories, emotions, plans, notions about what to do, where to go and with whom to interact are constantly being processed in the background. The results of these processes are sent onwards to other brain areas, which in turn send feedback to adjust the original message. Your subconscious, believe it or not, is always at it – forever considering new possibilities and finding solutions to your problems. Whether or not you become aware of the fruits of all this brain activity depends on what you're doing.

If your conscious thoughts are fully engaged with a conversation, performing a complex task, browsing a website, watching a TV show or reading emails on your smartphone in a busy cafe, then any ideas quietly bubbling up from the depths of your subconscious will probably end up going unnoticed. There are just too many distractions. It's a bit like trying to get the attention of a friend that you've spotted on the other side of a busy high street by whispering at them! The solution is to cherish, rather than squander, those rare moments of calm.

When in between conversations, in between tasks or in between absorbing trains of thought – those precious moments when there are no distractions whatsoever – *that's* when your conscious awareness is likely to be sufficiently unperturbed for those subconscious idea bubbles to cause a noticeable ripple. They're always there, gently breaking at the surface, but only in the lulls do they have a chance of getting noticed. This is why your greatest ideas, solutions to your trickiest problems, breakthrough moments in working around obstacles, tend to come to you when you're not up to much at all.

With your subconscious being so busy churning up ideas, theories and concepts that might come in useful, the trick is to quieten your brain enough to catch them.

Perfect timing

Sleep is vitally important when it comes to being innovative; the very best brain state for creative breakthroughs is when you're sound asleep. While dunking is how you can gain *access* to great ideas, they're almost certainly generated in the first place when you are sparked out, dead to the world and sound asleep. The "hypnagogic state" is when your brain is still *in the process* of falling asleep, but not *fully* asleep. So you're not only relaxed and quiet enough to receive any ideas that break to the surface of consciousness, but also importantly your memory banks are still online. The reason you don't want to fall asleep completely is because this wipes clean the slate of your most recent memories.

Falling asleep

Strange as it may seem, brains don't go into sleep mode all in one go. Instead, different parts fall into sleep mode at different times. As each brain region switches into sleep mode, one by one, it's no longer able to exchange messages with the other brain networks it's usually in close contact with. Parts of the brain not yet in sleep mode are effectively ticking away in isolation – each doing its own thing – but once the hippocampus goes into sleep mode (after about 20 minutes in most people) any bright ideas that popped into your head won't be remembered.

Whatever the precise reason for these fuzzy brain states generating such great ideas, we can feel confident that the hypnagogic state is our best bet for delivering the goods as it was so fruitfully exploited by Thomas Edison. He was without doubt one of the greatest inventors of all time. By the end of his career he had an incredible 1,093 patents to his name. To get there he first had to crack a particularly tricky problem relating to exiting the hypnagogic state just before entering the deeper state of sleep, beyond which all those great ideas drift away.

Enhanced creativity

Edison noticed that whenever he observed people falling asleep in public, at the very moment they "dropped off," their neck muscles would relax, causing their head to drop forwards suddenly ("nodding off"), waking them back up again. In fact, all skeletal muscles – those controlling movement of our arms, legs, body, neck and face – become paralysed when we fall asleep so that we don't kick ourselves awake when we dream about running for a bus.

This accounts for the wide open, fly-catching mouths and embarrassing trails of drool emerging from the slack jaws of those who accidentally fall asleep in public. Edison realised that this presented a great opportunity to provide a wake-up call at exactly the moment that any ideas would be on the brink of being lost forever to an overly long snooze.

His solution, as you know, was simplicity itself: holding metal balls in his hands as he allowed himself to nod off. Of course Edison knew that napping on its own wouldn't cut the mustard. He knew that he had to put in the hard yards first, tackling the problem head on by spending many hours tinkering, looking at the challenge from all angles, mulling over a variety of bizarre and wonderful possible solutions to the problem at hand. He would read broadly on the topic and talk to anyone whose expertise might shed some fresh light on the situation. Then, when he began to feel sleepy, still with all the reading, feedback from others and latest thoughts on the matter fresh in his mind, he would settle down, ball bearings in hand for his preplanned nap. The reason this strategy was so effective was that the balls clattering to the floor would wake him up just *after* he had dipped into the hypnagogic state, but *before* his memory buffers got wiped.

If you are doubtful about how effective Edison's homemade "creativity machine" really is, bear in mind that he is broadly credited with inventing the light bulb, the phonograph and the dynamic image camera. In other words, without his prodigious dunking-enhanced creativity, we would have had to wait around an awful lot longer for electric lighting, recorded music, TV and the birth of the movie industry. If it worked for Edison, then there's no reason why it shouldn't work for you too.

Hypnagogic update

If Edison's ball bearing technique seems a bit old hat, impractical or potentially embarrassing to you, then fear not – there is a simple way to update his method for the 21st century. The next time you find yourself giving a problem you'd like to solve some serious thought, settle down for a power nap and, depending on how good you are at nodding off, set an alarm to go off 10–20 minutes later. With a little practice, you should find yourself being able to enter into the hypnagogic state and exit just in time to find some useful ideas floating around in your head.

If you get in the habit of doing this once or twice a day you'll soon find that you start popping back up from hypnagogia automatically, just before the alarm goes off. At this point the alarm just becomes a backup. Please note that it's very unwise to give in to the temptation of setting your countdown alarm for longer than 20 minutes. Long naps often lead to feeling sleepier than you did beforehand, will interfere with your sleep later that night *and* any stunningly brilliant solutions will almost certainly have slipped silently beyond your grasp.

Where in the brain do creative thoughts actually come from?

One of the most creative brain areas for creative thought is on the *outer* surface of the brain in the dorsolateral prefrontal cortex (dlPFC stop – see Appendix for a look at the Outward-Facing Brain Tube Map) on your brain's Hold Line, roughly level with the upper right corner of your forehead. If you attach a bunch of electrodes to a person's scalp while they try to solve a series of tricky problems, a burst of electrical activity emanating from the dlPFC in the right half of the brain will peak a whole second before they actually realise they've found a correct solution. In other words, this appears to be a hub for all your unconscious, creative thought.

To further bolster this claim, a rather controversial study zapped the brains of a group of volunteers as they tried to solve a sequence of logic puzzles. They used a pair of electrical currents to either simultaneously deactivate the right PFC and activate the left PFC or vice versa. When the activity in the left PFC was dampened and the right PFC was boosted, participants could solve the logic puzzles faster and complete more of them, compared to those in whom the electric currents were applied the other way round. We'd like to make it perfectly clear here that we're not recommending self-electrocution for creative thought! (Frighteningly, though, such devices are being made available for public consumption, often marketed with the promise of improving performance in competitive video gaming.)

Using novelty to jolt you out of set-piece behaviours

The left PFC is generally most active when a person is performing tasks they are very familiar with – set-piece behaviours performed so many times before that they can be executed on autopilot. The right PFC, on the other hand, kicks in when a person needs to process new information, go to a new place or carry out a novel task. So if you want to get your right PFC firing on all cylinders to boost your problem-solving capabilities, you might want to go out of your way to seek out new experiences.

The corpus callosum is a thick bundle of 25 million brain wires that connect the left and right sides of your brain. It is the main pathway through which each side of the brain keeps bang up to date on what the other half of the brain is up to. Its existence is also the main reason that people who consider themselves to be very "left brain" or very "right brain" are almost certainly talking complete nonsense.

Try working in a new place, like a park, meeting room or café that you've never been to before, for an hour or two each week. Once in these fresh, novel environments, actively try to think of new solutions to old problems. If you can't spare the time to leave your desk, take a 5- to 10-minute break to surf the internet in search of photos and illustrations on an unorthodox subject or find a brain teaser website, purely to coax your right PFC into action by forcing yourself to do something new. If art and brain teasers aren't your thing, you might choose to go on a voyage into the world of experimental sound or listen to music from a culture that is exotic to you. The unfamiliar rhythms and cadences of songs in a foreign tongue may well be just the unusual sensory experience it takes to wake up the right PFC sufficiently to get those creative juices flowing.

How often have you found yourself in a situation where you've got stuck on a particular problem and, having reached what seems like a dead end, you're unable for the life of you to see any possible solution? Then, having walked away from it and done something completely different, you come back to it only to find the answer is right there in front of you, staring you in the face! It can be a struggle to understand why you weren't able to see it in the first place, now that it seems so glaringly obvious.

This is why, whenever you are trying to concentrate on something, it's best to do it in 45-minute chunks with a 15-minute break in between (or 90-minutes of work followed by a 30-minute break). For most people, working this way actually leads to greater productivity overall. You can keep up a rhythm like that all day long, rather than allowing your mental efficiency to gradually ebb away (whether you realise it or not) by not giving your brain regular opportunities to rest and recover. More often than not, trying to work nonstop all day leads overall progress to go backwards rather than forwards as you become more and more mentally fatigued. The key part of this strategy is to make sure the 15-minute break is only 15 minutes! Be sure to find ways to spend that short recuperation break doing something that lends itself naturally to getting back to work after no more than a quarter of an hour.

Switch it up

The best way to start thinking outside of the box is actually to physically get outside of your box. In other words, get out of your workspace! Some fresh air up the nostrils and a lack of walls and ceilings definitely induces some "corkscrew thinking." That's a term originally coined by Winston Churchill and still used today to describe looking *around* obstacles and barriers to find solutions.

Just as food always seems to taste better when cooked outdoors, thinking feels so much better when it's done outdoors too. If you want the ultimate outdoor meeting, try and hold it beside water, especially by water that creates a pleasant sound – for instance, by a fast-moving stream, river or waterfall or maybe even near the coast so you can hear the waves crashing in the background.

The reason this all helps with the creative process is because it is a fantastic way to wake up your right dlPFC. The critical feature of moving water is that it is constantly changing and unpredictable. Watching moving water or listening to the sound it makes involves following a complex, ever-changing sensory pattern that cannot be accurately anticipated from one second to the next. That keeps your brain's pattern detectors guessing and spurs the right PFC into action.

Brain shaking

Brainstorming, in its original formulation, involved getting everyone together to bounce ideas around in an environment where there is no judgement; everything is considered and no one is criticized for coming up with outlandish ideas.

What works much better is a "brain shake." Everyone considers the problem in their own time, coming up with ideas individually, writing them down and submitting them in advance of the actual discussion. Who came up with which idea must be kept strictly

anonymous. (The ideas should ideally be typed up or copied out by one person so that the handwriting doesn't give the game away.) When the group meets to do the brain shake, each idea is read out and everyone votes for the most interesting options. The group is then randomly divided into two teams; one team dreams up arguments in favour of the most popular idea (according to the vote) and the other team argues against it.

This approach is superior to the classic brainstorm primarily because *critical appraisal* of any idea is absolutely vital. Keeping it anonymous means that nobody gets shamed during the critical step of flagging weaknesses as well as strengths. It also avoids the threat of a person's status getting in the way of objective evaluation of the ideas. In other words, you avoid the situation where everyone sucks up to the boss by praising their idea rather than usefully poking holes in it and the good ideas of low-ranking staff don't get ignored. Our acute awareness of where everyone is in the pecking order can really get in the way of innovation!

Randomising the members of each debating team is very important. It means you get people who hate the idea dreaming up arguments to support it as well as those who think it's a good idea. You also get people who love the idea having to come up with arguments to help those who hate it rip it to pieces. This maximises the diversity of perspectives taken during the critical evaluation of each idea, which makes a huge difference.

What is also key for a good idea-generating or problem-solving session, whether it's indoors or outdoors, is to really disrupt the status quo – agitating and invigorating minds with something new – and to encourage the people involved to have some fun. Many businesses are sceptical of the concept of having fun at work. But punctuating serious work with a little bit of frivolity genuinely breaks down the mental boundaries of rigid thought and improves the flow of ideas.

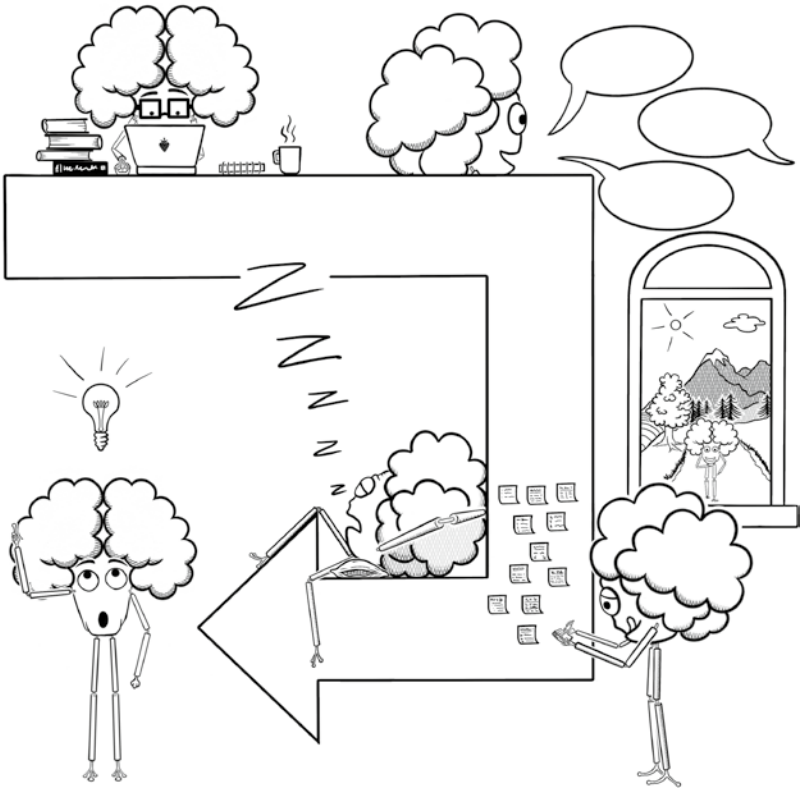
If people are given the opportunity to have a laugh, they become physically relaxed and less self-conscious. This not only gets them ready to receive the ideas bubbling up from the depths of their subconscious brain, but also facilitates the process of getting the ideas circulating more fluidly around the room.

When people start laughing and joking in a meeting then there's a fair chance that the seed of an idea is about to sprout. Cracking a joke that gets people laughing usually requires quick thinking, identification of an unexpected association and perfect timing – it's a highly creative process in its own right. People may laugh, but then realise, "Actually, that isn't such a daft idea!" All too often, solution-finding meetings get brought to an abrupt end because it seems people aren't taking it seriously enough – a big mistake. In creative enterprises it is extremely important to take the positive impact of fun on the process of innovation very seriously.

Off-site meetings really do create that much needed novelty factor to help bump-start the mind; just try to avoid the trap of always holding them in the same place for the sake of convenience. Just like when training your body in the gym, it's good to vary your exercises, so get people to do something different, to flex mental muscles not usually involved in your set routines.

Inputting data to feed the Eureka moments

If you think that all your problems will be solved with a quick crossword and a nice nap then you've skipped over one vital step in the process. If you want to unleash your subconscious on something, you must first put the work in. It's down to you to input the relevant data so that the novelty-processing, creative brain areas have the raw materials they need to find a solution to the problem.



The more you research a problem – the more you read books and articles, scour the internet, contact experts, discuss and bounce ideas around with friends, colleagues, families or anyone who will listen – the more your subconscious will get busy working on it. The more varied and diverse the group of people you bounce your ideas off, the better. The trouble is, with so many distractions to lure us away from this information-gathering process, it can be hard to get enough relevant data into your brain in the first place.

French mathematician Henri Poincaré found a solution to this problem by carving out certain periods of the day during which others could not disturb him under any circumstances. The consistent, regular timing of these "focus periods" in his schedule allowed his brain to get into an appropriate rhythm and, perhaps even more importantly, other people in his life soon got used to him being unavailable to them at particular times of day.

In his case, 10 am to 12 noon and 5 pm to 7 pm were the time slots he devoted to working solidly on mathematical problems. Then, in the evening, he'd read broadly around the many different subjects that interested him, perusing books and journals on physics, engineering and philosophy of science – freestyle research, so to speak. The key clue that solves a problem is often to be found in the most unexpected of places. The final piece of the puzzle that leads directly to a breakthrough often has nothing to do with the subject in question.

During my post-doctoral research in Germany, back in 2009, I'd been making great progress with my experiments over the first few months, only to hit a nasty wall that was threatening to derail the whole project. For weeks I tried to solve the problem to no avail and was becoming increasingly convinced that I'd wasted many months of my life on a brain imaging study that would never actually work.

When I eventually made the breakthrough that saved the day, I found the vital clue that helped me locate the root cause of my problem in the most unlikely of places. One afternoon I was lying in the bath reading a novel by Douglas Adams (who famously wrote the Hitchhiker's Guide to the Galaxy*) and right before my eyes – in the tale of* Dirk Gently's Holistic Detective Agency *– was a description of a phenomenon that was of immediate relevance to my problem: two overlapping waves interfering with each other. Like Archimedes, I jumped out of the bath and ran to the lab as fast as my legs would carry me. Unlike Archimedes, I remembered to get dressed first. My aha! moment allowed me to type just two extra lines of computer code and then my experiment started working perfectly. Eureka!*

– Jack

Novels, art exhibitions, song lyrics, chatting to a neighbour, watching birds flying or squirrels leaping though the trees – clues that help to reveal the solutions to your problems lie in the most unlikely of places. The key point here is to be tenacious, never give up hunting for inspiration and always keep your eyes, ears and mind wide open, forever on the lookout for new and unlikely connections.

Archimedes famously climbed into an overly full bath and, noticing that his body caused some of the water to overflow, a brilliant idea came to him – and one that helped him solve a very important problem. Noting the relevance of seemingly unrelated occurrences to the problem at hand can be enough to trigger a flash of inspiration that leads to a Eureka moment. This is the essence of creativity.

Poincaré's greatest creative moment – when he solved a problem previously considered by the best maths brains around to be impossible – came to him as he was stepping onto a bus. The bubbles of original thinking are quietly breaking through to the surface, only noticeable in the gap between adjacent thoughts. That elusive aha! moment will invariably strike when you are thinking about something completely different and quite possibly miles away from your place of work.

Night shift

When you sleep there's far more going on than just repair and maintenance of brain cells. You wouldn't believe how much work is involved when it comes to making, breaking and bolstering connections at the synapses between cells. This is the basis of learning new skills and forging long-term memories.

During each of the many sleep cycles we go through every night, test signals are sent down the new circuits to ensure that the correct cells are wired together, once new protein-based mechanisms have been triggered to strengthen the influence of one neuron over the next in line. You might be snoring away, but for your brain's vast infrastructure improvement workforce, it's all go.

This is where dreaming comes from: reactivating the same brain pathways that were stimulated earlier that day, to replay certain events so that they can be combined with fragments of relevant existing memories. But in the absence of light coming in through the eyes or sounds stimulating the ears, these experiences are no longer properly anchored to reality – which is why such bizarre things can happen in dreams. When your brain is in sleep mode, it is far from idle. It's shifting up and down through the gears like a manic racing driver, but a driver in a simulator rather than out on the track for real.

You can tell when someone's dreaming because their eyes dart around under their eyelids – a phenomenon known as rapid eye movement (REM). During REM (dream) sleep, our new memories become integrated with those already locked away in our memory banks – a process called memory consolidation.

This is also the phase of the sleep cycle where negative emotions are stripped away from any upsetting events that might have happened to us during the day. This is achieved by reducing the production of noradrenaline – an important brain chemical usually released when we feel threatened. Once that important work has been done, we can think back to those events and learn from them, but without feeling quite so upset about it.

Not only does REM sleep help us to feel less anxious, but our ability to interpret other people's body language is also improved when we get plenty of REM sleep. Just a few reasons why getting a good night's sleep is so important.

The longer we sleep for, the longer our REM sleep phases last. This means that people who get six hours rather than eight hours aren't missing out on 25% of the REM sleep they could be getting, but more like 30–40%! Such people should avoid napping like the plague. By avoiding naps, sleep pressure will build over the course of the day, making it easier to sleep at night.

During deep sleep the eyes *don't* dart around like crazy like they do in REM sleep, so this phase of sleep is often described as non-rapid eye movement (NREM) sleep. Deep sleep is where the most important of the new memories from the day are amplified so that they can be integrated into our memory banks during the next round of REM sleep and be more easily recalled the next day. NREM sleep is also a period during which toxins are removed from the brain at *twenty times* the rate of other parts of the sleep cycle.

Each full sleep cycle involves going into NREM sleep and then coming back up into REM sleep, taking around 90 minutes on average to complete in most adults. So we can get through many full cycles each night and benefit from both phases of sleep, each of which do very important work throughout our brains.

Rest and play

A major problem for many modern brains is that life doesn't allow people who work for a living much time for rest and play. The work bit, whether it's actually work, commuting to and from work, running around catching up with personal affairs or keeping on top of day-to-day chores such as shopping, paying bills, and so on, really does get in the way.

The key thing to remember is that brains benefit from rest and play in equal measure. When you get the balance right, it makes them far more efficient and effective when it comes to the work bit. Play enables your brain to lock into a less rigid mode of thought compared to how it typically functions during periods of work. Instead of trundling through the same old set-pieces, it is better able to invent new ones. Really useful, positive play for any brain involves its owner moving out of their usual environment, trying a new experience or activity somewhere else and, above all, really throwing themselves into the task wholeheartedly, while being mindful of the importance of banishing all self-consciousness. The more often you do it, the easier it is to achieve.

Release the prisoner!

I spent six years researching phenomenally successful people and I discovered that they all have the natural ingredients of success that we as young children all once had in abundance – before we went to school! We, as curious preschool youngsters with vivid imaginations and no mental obstacles in our way, never stopped asking questions, but also we never stopped playing – no matter where we were or who was watching!

Then, having entered through the school gates and become prisoners of other people's thinking, we had to grow up all of a sudden. The great news is that, deep down inside, we all still possess these childlike qualities. The challenge is to find the best ways to coax them back out again.

– Adrian

Go jump in a few puddles!

By releasing the positive qualities we had as young children, including a love of engaging with imaginative flights of fancy, our brains will experience much needed novel stimulation, driven by the aim of being more inventive. So if you really do want to be radically innovative, you'll probably need to strip away a few layers of conditioning that were intended to make you more sensible – conditioning that, unbeknown to you, has entangled you in its net and restricted your natural urge to play.

It could be said, then, that the success of an individual is largely down to having a ferocious appetite for answers, coupled with a childlike, unimpaired outlook. Having a hard-working, conscientious, determined attitude is of course also vital. However, looking at it through the lens of science, we can see how important play is for solving problems and creative thought. Play entices your brain to process novel situations and

be more spontaneous, activating areas that facilitate the insight required to find common ground between seemingly unrelated ideas.

Forcing your brain to process a vast array of novel stimuli, through being playful, adventurous and more spontaneous, is the bedrock of creativity.

Chapter takeaways

- Are you receiving, over? Your brain is always coming up with solutions to problems and providing a constant stream of ideas. But are you tuned in?

- If you're going to give dunking a go, don't stay dunked too long – set an alarm so that you don't go under for more than 10–20 minutes.

- Your chances of resolving a problem will be greatly enhanced if you have got your subconscious on the case by inputting all the relevant data it needs to get to work on.

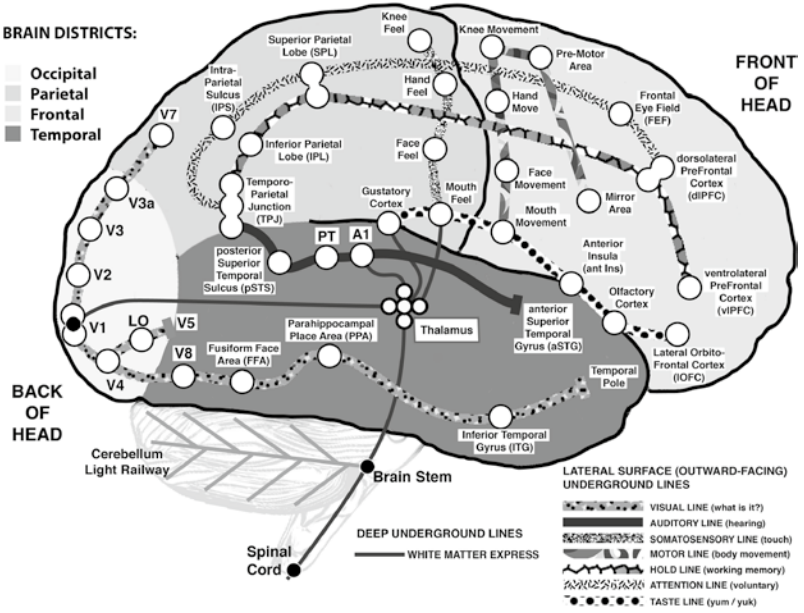
- Your brain loves novelty and thrives on it. If you're in need of a creative boost, step away, get out of your box, do something different – preferably something that's a bit random, novel, spontaneous and fun.

- When your brain is sinking into sleep mode, that's when it's at its most creative. Aiming for eight hours sleep a night is a great idea if you want to get the full benefits of memory consolidation, toxin removal and brain repair!

Perception Is Everything

Now you see it, now you don't

The retina, at the back of your eye, is an extension of your brain. We may experience the sensory world as if the sights our brain creates from the light striking the retina is a faithful representation of what's going on out there in the real world, but in actual fact this is an illusion. A very convincing illusion admittedly, but an illusion all the same. All sorts of shortcuts and ingenious neural strategies are used to fill in the gaps wherever the brain does not have enough information to do a decent job of capturing reality as it really is.



Of course, under normal circumstances, the brain is so good at faking it that we are all under the distinct impression that what we see is an accurate portrayal. But it's not always the case. What we see is actively created by a large, dedicated part of the brain called the Occipital Lobe, situated right at the very back of your skull. If you take a look at the Occipital District on the outward-facing brain tube map, you'll see how many different stops on the Visual Line are required to create the illusion of sight. And there are loads more in the Temporal District too.

Window to your brain health

Recent research has revealed that our retinas can provide useful insights into the health of our brains. Easily observed features at the back of the eye can be used to assess the risk of stroke, the onset of multiple sclerosis and the progression of mild cognitive impairment.

Your permanent blind spot

Only the very central part of wherever you point your eyes is crystal clear. Everything else, believe it or not, is totally blurry. And only the central part of the retina (the fovea) can see in colour. Everything else is seen in black, white and shades of grey. If you hold both your hands out in front of you, at arm's length, with both thumbnails in the centre of your field of view, that's roughly the area covered by the fovea. Only the fovea has the cone-shaped light detectors that are sensitive to red, green or blue light and only in the fovea are these light detecting photoreceptors packed densely enough to give you high-resolution vision.

If this is true, then why does it feel so very much like you *can* see detail and colour in the periphery? Well, this is because your eyes are constantly darting around capturing high-resolution colour information with the central fovea. These snapshots of different parts of the scene linger in

perception to enable your brain to piece together an impression of the bigger picture. These eye movements happen so fast that you are completely unaware of them. We are so adept at automatically shifting our gaze around to allow our fovea to harvest light from an interesting blur in the periphery and then back again that we don't even realise it's happening. Your brain even fills in the gaps between snapshots taken by the fovea with an overall image that makes sense given the context of the overall scene. Vision really is an incredible feat of perceptual magic.

O X

If you remain unconvinced, try this. Cover your left eye and with your right eye look at the "O" above. Then, slowly but surely, move the page towards you. Just before your nose touches the page, the "X" will disappear. That blind spot (where the optic nerve leaves the eyeball leaving no room for any light detectors) has been there your whole life. Usually your brain effortlessly "wallpapers over" this gap in perception, no matter what you're looking at. Truly amazing!

Wiring up the senses

A newborn baby is not born with the ability to see as we adults do. A baby's vision is about one-twentieth of the resolution of an adult's – which means everything's extremely blurry. The part of the brain that does the seeing actually *learns how to see* as the connections between brain wires in the occipital lobes and beyond are honed according to whatever patterns of light hit the retina during the first few months of life outside of the womb.

During the first six months to one year of life, a newborn's brain creates 990 trillion new connections between its brain wires (aka neurons). Consequently, the infant's prefrontal cortex uses twice as much energy per cubic millimetre as that of an adult!

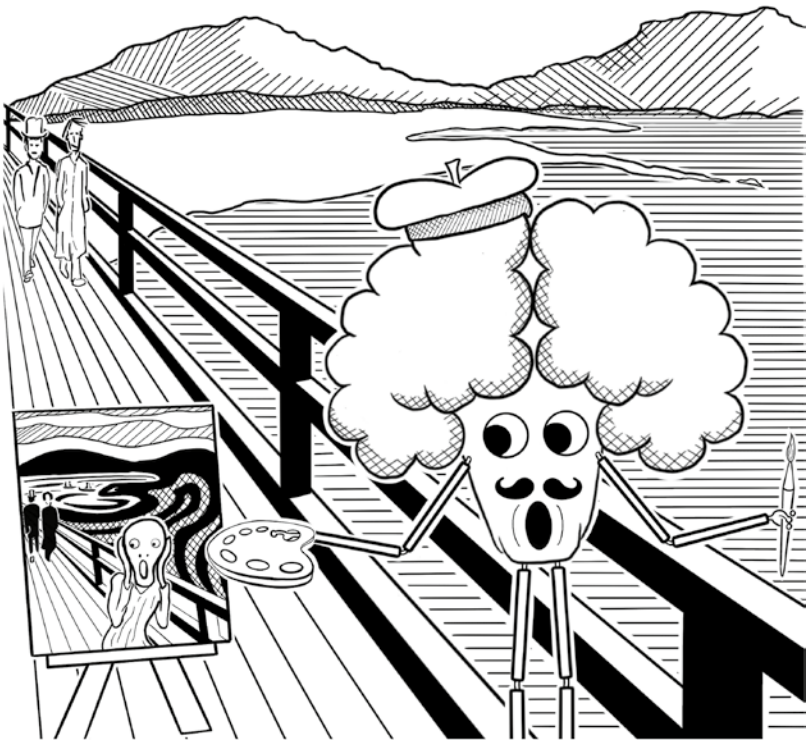
Hearing is a slightly different matter. An unborn foetus in the womb starts to respond to sounds in the outside world during the third trimester. The connections between brain wires in the Temporal District's Auditory Line – those that actually create what we hear from the vibrations that reach our ears – get a three-month head start over those in the Occipital District. We know this thanks to one particularly observant mother who noticed that her unborn child always changed its behaviour the very second the theme to a famous soap opera started playing on the television every weekday. It's a similar deal with taste. Mums who snack on aniseed-flavoured food and drink during pregnancy find that their baby ends up with a preference for that flavour after birth.

A surprising amount of progress is made in the womb when it comes to wiring up our senses and this process only accelerates in the first few years of life. After a child's brain has made some headway, developing its sensory abilities yet further through active exploration of its environment, somewhere between the ages of 12 and 20 months it starts to develop a sense of self. Strange to think that we had no concept of "I" or "me" throughout our first year. No wonder we don't remember any of it.

Division of labour

Different areas along your brain's Visual Lines each have a complete map of visual space and each extracts different features from any given scene. The brain stop known as V4, for example, is a densely woven network of neurons that actively extracts colour information from the light that hits the fovea. We know that in rare cases where V4 has been damaged in both halves of the brain, a person will lose the ability to see in colour.

They see more or less the same patterns of light and dark regions that make up the objects, faces and landscapes, but they are composed entirely of shades of grey. This is because one of the tasks that area V4 evolved to perform is to compare the wavelengths of light in adjacent patches of retina and then "paint" in the colour information into the visual scene conjured up by all the other parts of the visual brain. Without V4 doing its job, we simply cannot see colour.



Outside of your brain (or anyone else's for that matter), there's no such thing as colour. Light has no colour in and of itself. What you see as colour is an interpretation your brain makes to attribute colour to different wavelengths of light reflecting from adjacent patches of space. It's a cunning illusion that helped us to stay alive by making us better able to spot food and predators, but it is all in our minds!

At night our peripheral vision is better than central vision. That's why sometimes you can see a faint star in night sky just to the side of where you're looking, but then when you try to look directly at it, it disappears! The reason is that the most sensitive light-detecting cells (rods) are more densely packed outside the fovea than inside it (to leave plenty of room for the cone photoreceptors that give us our high-resolution daytime colour vision).

Another stop on the Visual Lines is V5, located at the border between the Occipital and Temporal Districts. Its job is to create the perception of moving objects. Again, in those rare cases where V5 gets damaged on both sides of the brain, a person can see stationary objects, but as soon as an object starts to move, it disappears! It remains invisible until it comes to a standstill, at which point it suddenly reappears as intact areas of the visual brain kick in again.

Whenever you hear a particular song played on the radio, the Auditory Line, which runs along the upper part of the Temporal District, creates the sounds that you hear. There is good evidence that a division of labour also occurs in these brain areas. Some parts respond best to individual tones of a given frequency (A1 stop); others prefer sweeping sounds that progress from a low pitch to high pitch or vice versa (PT stop). A further division of labour was made evident when an unfortunate advertising executive ended up with damage to a specific part of his brain that robbed him of his ability to perceive music. He could hear voices, cars, the rustling of leaves in the trees with no problem, but music just sounded like a garbled mess of noise.

When you get a waft of a certain scent as you walk into a café, the smell you're perceiving is generated in the outward-facing part of the Temporal District (the olfactory stop) in response to the stimulation of airborne chemical receptors in your nose. Specific smells or "olfactory experiences" can often be powerfully associated with a certain person, place or life event.

You have 12 million olfactory receptors in your nose to detect the wide variety of different types of airborne chemicals that we experience as scents. Your average dog, on the other hand, has 1 billion, but bloodhounds really take the biscuit – with an astonishing 4 billion!

Smells can be particularly evocative when it comes to triggering emotional personal memories because the olfactory bulbs, which collect up the chemical information from many different types of chemoreceptors in the nostrils, plug directly into the Limbic Line. None of the other senses have such direct access to this emotional memory-generating and retrieving stretch of the brain tube map. Information headed to the other senses is first passed through the thalamus for preprocessing – a mind-bogglingly complicated junction box of brain wires.

Bottom-up and top-down brain pathways

Over 70 years of neuroscience research has taught us that "bottom-up" pathways take information from the eyes, ears, mouth, nose and skin to "higher" brain areas that actively create our perceptions. They first convert physical disturbances caused by light, air pressure variations (sounds), liquid and gaseous chemicals binding with special receptors (tastes and smells), different types of physical pressure or temperature (touch) into electrical impulses that your brain can use to construct your impressions of the world.

These include the visual pathways we considered earlier, which deliver the electrical pulses generated in the retina to the very back of the brain in the Occipital District (via the thalamus). Different patches of Occipital Cortex extract different types of information from this input, each crunching the signal to produce different aspects of our visual experience.

Similarly, the inner ear separates out air pressure waves reverberating at different frequencies and converts these mechanical forces into electrical messages that the Auditory Line can divvy up to extract different acoustic features in the A1, PT, STG and STS stops. Some platforms at the A1 stop produce our experience of high-pitched sounds, others low-pitched sounds and the ones in between produce the sound of middling pitch.

What we haven't yet considered are the "top-down" mechanisms that help us to shape the incoming sensory information in light of previous experience. These bring into the mix certain assumptions about what types of sights and sounds are likely to occur in different environments. As we gain experience of different places, we can start to anticipate the types of sensory experience that are typical in any given place, which dramatically speeds up the process of crunching the data. For instance, imagine taking a stroll in a park at dusk and you hear a creature scrabbling around in the bushes. When you direct your eyes towards the source of the noise, you can't quite tell what it is because it's dark and some leaves are partially blocking your view. This is where the top-down brain mechanisms can really help to narrow down the possibilities. They fit the vague outline of the critter in question into templates consisting of the types of creatures previously encountered in similar environments in your life so far.

Thanks to this top-down filtering out of the unlikely solutions, you'll soon find yourself feeling pretty sure that it's either a cat, squirrel, fox or bird, having automatically excluded the possibilities of a tiger, rhino, monkey or scary monster. Small children, who haven't yet accumulated enough sensory experience of what they are and aren't likely to encounter in any given environment often get the wrong end of the stick. You – with more experience and a more sophisticated top-down perceptual filtering mechanism – will have a much better chance of identifying the animal accurately.

Sound the alarm!

During World War II, researchers found that radar operators performed completely differently in the context of training exercises as opposed to real-life combat situations. During actual combat there was a vastly increased incidence of false alarms, with operators concentrating so hard on the screens in front of them that they would often imagine blips on the screen that simply weren't there. These false alarms may have been a bit of an inconvenience but at least they rarely missed the approach of a genuine "incoming" bogey.

Conversely, in training there was no problem with false alarms, but a far greater incidence of real blips on the screen being overlooked.

This highlights how our expectations can have an enormous impact on how sensory information is evaluated. During training the operator knows that a blip isn't *really* the approach of an incoming enemy. They also know that consequences of missing a blip in these practice scenarios are relatively mild – perhaps a reprimand from an instructor or a low score on the test. In other words, the "response threshold" (to use the official term) is higher under these circumstances than in a real-life situation, so the decision to sound the alarm is only taken if they were *sure* they saw it.

When carrying out the same task while patrolling the seas in wartime, on the other hand, the "response threshold" is lower and so much more easily triggered. The radar operator knows that any blip could genuinely pose a deadly threat to life and limb. The consequences of missing a single blip are unthinkable, which is what causes the response criterion to drop significantly. The outcome is that even the dimmest-looking, fleeting, half-imagined blip on the screen has a good chance of sending everyone scrambling to battle stations.

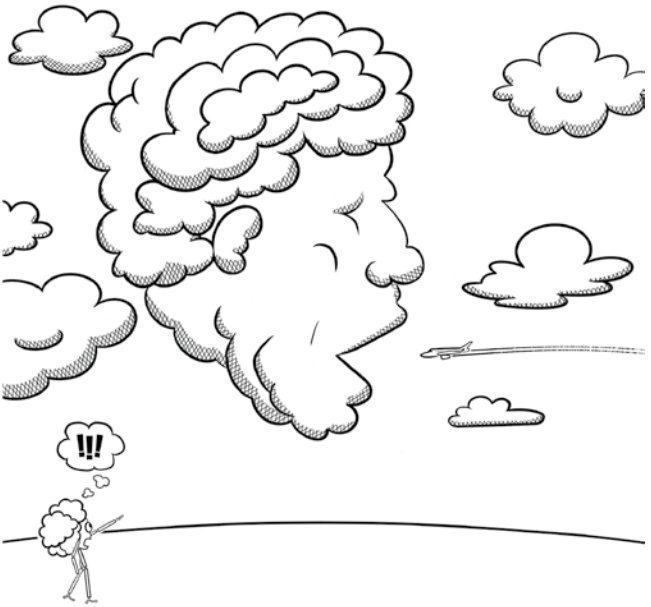
Do I know you?

Due to its immense importance to an extraordinarily social species like us humans, we have a specific piece of brain real estate dedicated to processing faces. The primary function of the Fusiform Face Area (FFA stop) is to extract meaning from anything that looks like a face. Given how reliant we have always been on each other for survival, over hundreds of thousands of years of cooperative living, it is perhaps unsurprising to think that evolution left us with a dedicated patch of cortex for identifying and distinguishing faces within a split second. There are clear advantages to being able to quickly establish whether an unexpectedly encountered face is friend or foe. That this potentially life-saving ability was key to the

survival of our ancestors is proven by the fact that we all have it quite literally woven into the very fabric of our brains.

That said, when we come to associate certain faces with certain places, the top-down assumptions that usually help to speed things up can actually let us down. If a colleague we once worked with turns up out of the blue when we're on holiday, we'll often find ourselves completely stumped as to why they look so very familiar. We can have a strong sense of familiarity, but with no contextual cues to help us resolve the conundrum of exactly where we've come across that face before, we just can't work out who they actually are.

As we all know, this can be really embarrassing, especially when they recognize you, start chatting away and, horror of horrors, refer to you by first name! You stand there, desperately trying to place them, not knowing whether to bluff it or come clean and ask them to remind you of their name. The crunch point usually comes when you suddenly find yourself having to introduce them to someone else and you're left with no choice but to confess!



Having a special brain area dedicated to faces can also lead to situations where we see a face when in reality it's not really there – in the clouds, for instance or in the corner of the bedroom when we were six years old and scared of the dark. Low levels of illumination provide less information to the eyes for the brain to use to define where one object ends and another begins. In these circumstances such vague and incomplete information can result in the eerie sense of a ghost-like presence in a darkened bedroom. When our imagination gets the better of us (top-down), we can assemble the vague blurs formed by a variety of separate objects (bottom-up) and end up creating the distinct impression of a monster's head staring at us, when in fact there's nothing really there but a crumpled dressing gown or an ornament poking out from a bookshelf. Our brains are constantly looking for patterns in perceptual information and often find them even when they aren't really there!

Mind the gap

Certain strong perceptions can end up being paired to create potent associations. These associations can lead to what we usually describe as expectations. Even a single word can lead to a whole set of assumptions; a notable example is a major online retailer that once had a large button in the middle of their website landing page with the word "Register" on it. Simply by replacing this with the word "Continue" they saw an increase in revenue of 300 million dollars in just one year. While "Register" results in the expectation that we'll have to waste time doing things like filling in forms and laboriously typing in a load of personal information, the word "Continue" promises a more satisfying feeling of progress, of moving quickly onwards and getting somewhere sooner rather than later.

A deceptive encounter

As a result of assumptions that become associated with certain categories of perception, we all develop preconceived ideas about certain types of people; ideas that often prove to be wrong. Many years ago,

(Continued)

while driving from London to Somerset, I stopped off at a busy roadside café. Shortly after I'd placed my order, a man I can only describe as the biggest, scariest-looking human being I'd ever seen came in and took a seat at an adjacent large round table. When he turned around to talk to the waitress, the words HELLS ANGELS were clearly displayed on the back of his jacket.

He placed his order but, before it arrived, he got up and disappeared into the toilets. Whilst he was in there a group of five distinguished-looking, older gentlemen wearing bowls club blazers came in. The only place for them to sit together was at the large round table, on which the currently absent occupant's breakfast had now arrived. Seeing this, the five bowlers asked the waitress if anyone was sitting there and she replied "Yes, there is a gentleman sat there but I'm sure he won't mind if you join him."

Obviously happy with this, they all took a seat. It may sound cruel, but I could not wait to see the reaction on the faces of these five old boys when the man reappeared. When he did eventually return, I was not disappointed! On seeing the colossal "being" who was now suddenly towering over them, they all, wordlessly, jumped up, kicked their chairs back and shot off to find another table – as far away as possible.

Having had his breakfast, my Hells Angel neighbour pulled out a copy of The Times *and started finishing off what looked like an almost completed crossword. Noticing that I was watching he smiled at me and in a very soft, extremely well-spoken voice said: "Crosswords are always a bit of a struggle on a Monday morning!" We got chatting and it turned out that, having left Oxford University, he'd gone travelling, eventually ending up in Rwanda, where among other things he'd been working with landmine victims. He was one of the most intriguing people I've ever met, an unforgettable, fascinating character. He was the inspiration behind my Pineapple Person character – from a previous book – those who are spiky on the outside but very different on the inside. How wrong we can be in our assumptions!*

– Adrian

Before we move on, a quick question for you. When you think of a wind farm, what picture springs to mind? Is it one of something that's clean, natural, positive and safe or is it one of something that's man-made, monstrous and damaging? Our associations with a concept like wind farms can lead to a variety of assumptions that polarise our opinions and, once formed, leave us blind to the truth.

So what has this all got to do with sorting your brain out? It's all about that gap between the bottom-up and the top-down mechanisms. This is where mistakes happen. And the better you understand the quirks and shortcomings of this gap, the less likely you'll be to place too much faith in what your senses tell you and the better you'll be able to appreciate when others fail to "Mind the Gap."

Consider the mind-boggling complexity of the challenges facing your Occipital District when having to conjure up a convincing 3D visual world on the basis of a 2D array of light-detectors at the back of each eyeball. You can only begin to imagine the technical difficulties involved in capturing the sound of an 80-piece orchestra from a bunch of air pressure variations coming in through just two tubes. Or, for that matter, contemplate the finely tuned interpretation of the information from chemical detectors of the nasal passage and tongue, carefully integrating the delicate flavours that comprise the experience of a delicious meal.

These systems are not 100% reliable. Your senses can trick you. People who place too much confidence in what their senses are telling them about the outside world end up misreading situations, looking and feeling silly in the long run. Beware the assumptions that the brain constantly makes about what is and is not likely to exist in any given environment. Exceptions do happen.

Impacts of context and expectations on perception

Pleasant smells, foods and even music induce responses in the OFC brain stop – part of the Frontal District sitting just above the eye sockets – which

mirrors in real time how satisfying your sensory experiences are. We know this because neuroscientists have scanned the brains of hungry test volunteers when they were fed bananas. Large responses in the OFC occurred as they chomped on their first banana, reflecting the pleasure they derived from satisfying their hunger. However, once they were stuffed silly and asked to eat yet more, an additional banana produced significantly reduced responses from the OFC, reflecting the decrease in enjoyment when consuming exactly the same food, but under different circumstances.

TV wine experiment

A few years ago I presented a prime-time TV series for Sky One and in one episode we treated volunteers to a free wine tasting. We took two bottles of wine, one an expensive-looking bottle of gold-medal-award-winning, limited-edition, grand cru Bordeaux and the other a cheap, unimpressive-looking bottle of generic plonk. We then poured the contents of both down the sink!

Both bottles were then refilled with a mid-range, mid-cost, decent but not amazing red wine. We then asked unsuspecting members of the general public to taste each of our wines while they were wired up with EEG electrodes to monitor brain responses to these two "different" wines. Participants were asked to say what they thought of each wine and compare their flavours, aromas and perceived quality.

What do you think happened? Did they cotton on to our little ruse? Might their sensory experience of exactly the same wine twice have given the game away? Not a chance! Their expectations – having been set up not only by the different appearance of the bottles that stood alongside each glass of wine, but also an elaborate and completely

fictitious tale about where each of the wines came from – unanimously tipped the balance in favour of the wine poured from the "posh"-looking and -sounding bottle.

What they had to say about the flavours and aromas of each wine were very different. The wine from the "posh" bottle was described in glowing terms as tasting of berries and other sweet fruits; deemed "well worth" the £40 price tag. The wine from the "plonk" bottle was said to be bitter, acrid, entirely unimpressive and so they were unsurprised that it retailed for a mere £4.

Our expectations of the pleasure a given product might give us can have a profound impact on how we actually experience it – so long as there are no powerful and obvious sensory signals to negate that expectation. If we had used the cheapest imaginable wine, alarm bells might have sounded. Equally, had the wine been of the highest possible standard, they might have struggled to accept that something so delicious could cost a mere £4. However, as there was no major disparity between their expectations and their experiences, their testimonies matched their assumptions perfectly.

– Jack

Other studies have indicated that the OFC does not respond to enjoyable sensory stimuli per se, but rather how enjoyable you *anticipate* they will be. OFC activations in response to a certain pungent odour were significantly increased when test volunteers were told it was the scent of an expensive cheese compared to when they were told it was a stinky pair of socks. Same odour, completely different response in the OFC, reflecting how powerful expectation can be in influencing the pleasure a person feels during their perceptual experiences.

Expectations can fundamentally influence your experience of sights, sounds, smells, tastes and even touch, both positively and negatively, according to how they impact on the responsiveness of your OFC. It can be helpful to consider these points when you're visiting restaurants, bars, pubs, hotels, shops and other places where there is a clear financial incentive to manipulate your expectations to steer you towards the more expensive options.

The sales pitch, whether it is somebody telling you an enticing story about a product or even just the way it's presented – in terms of lighting, music, scents pumped into the air and so on – are all ultimately aimed at influencing your top-down processing mechanisms to nudge your sensory impressions in the most profitable direction. Bear all this

in mind by trying to be sceptical about what sales staff tell you about their products and you'll start seeing through all the smoke and mirrors in no time.

Below expectations

Another glowing example of context leading to immensely misleading assumptions was when, one cold January morning during rush hour, a man started playing his violin, busking in a busy Metro station in Washington DC. After 43 minutes only a tiny handful people, out of 1,097 passersby, paused to listen. The sum total of earnings he made during this time was just over $32. The man in question was Joshua Bell, one of the world's finest and most respected violinists, who only three days previously had sold out Boston's Symphony Hall, at an average price of $100 per ticket.

Chapter takeaways

- Sights, sounds, tastes, touch and smells are actively created by your brain, often from incomplete information. They do not always accurately reflect reality.
- Mind the gap between your bottom-up and top-down sensory processing mechanisms. Much "filling in" between the two leads to faster, but sometimes entirely misleading, perceptions.
- Your brain is constantly looking for patterns and often finds them in perceptual information even when they aren't really there.
- Context can fundamentally change the way we perceive the world; fear in particular can play tricks on the imagination.

- Assumptions can change the way we interpret our perceptions – scrutinize your perceptions more carefully and you might start to see the cracks.

- Expectations fundamentally alter the pleasure we derive from our perceptual experiences, so think carefully about how you manage others' expectations and how they might be managing yours.

To Do or Not to Do

Icebergs of hindsight

Decisions, decisions, decisions! Everywhere you look there's a decision to be made. Faced with an ever-expanding list of choices, modern-day brains are forever having to make them: some large, some small, some easy and some not.

Most decisions are made without you even realizing it, with most of the action taking place deep down in your subconscious. Your conscious thinking on any given matter has an estimated capacity of 40 "bits" of information, while the subconscious processing capacity is estimated at a whopping 11 million bits. In other words, the tip of your decision-making iceberg – the part you are conscious of – is tiny compared to the immense information processing power that is constantly churning away beneath the surface of your awareness.

The first *you* get to know about what's going on deep in the decision-making circuits of your brain is usually when, after much subsurface deliberation, a conclusion has already been reached.

As a rational person, it really does *feel* like you are in the driving seat, carefully considering your options, but there is ample evidence to suggest that this feeling is misleading. Most of the explanations you might give for why you made a certain choice are entirely retrospective, the decision having already been made before you've even had a chance to consciously mull over the pros and cons.

When you think you are making a logical, well-thought-out decision, most of the time you're usually just attaching a reasonable-sounding

explanation to a decision you've already made largely on an *emotional* basis. The feelings that draw you towards one option over the others are the only access you have to the conclusions reached at a subconscious level. The explanations that you come up with to rationalise your motives tend to be stretched and squeezed and bullied into a shape that fits with your gut instinct on the matter.

Strange as it may sound, instead of thinking something through first before reaching a cogent decision, more often than not it's the other way round – you're unwittingly looking back in hindsight at a decision that your brain has already put to bed. This might sound a bit scary, but fear not: you *can* muster some control by taking steps to influence which raw materials are most readily available for your subconscious decision-making networks to get to work on.

Got a hunch?

With icebergs of hindsight in mind, and taking into account the huge influence of your expectation-influenced perceptions, what you might regard as being "gut feeling" decisions are in fact the result of an awful lot of behind-the-scenes hard work by your 24/7 brain. Thanks to its uncanny ability to learn from past experience, it's hardly surprising that when you trust your instincts in types of decision you've made many times before, you are often proved to be right!

Heads or tails?

Next time you flip a coin to force a decision, ask yourself, while it's still in midair: which way are you hoping deep down it's going to land? Sometimes this is the best way to gain access to the secretive inner workings of your subconscious decision-making processes. If you feel disappointed that it didn't land tails up, then you've got a clearer insight into the conclusions reached just under the surface of your awareness!

Circumstances in which your gut feelings guide you well usually occur in situations where you have amassed extensive prior experience. If, for example, you have accumulated hundreds of hours of experience on the paintball battleground, your instincts will have become honed to know exactly when and where it would be unwise to suddenly stand up, or go poking your head through an inviting gap, no matter how strong the temptation. Either through learning the hard way – with a painful splatter of paint – that certain locations are particularly exposed, or better still, learning vicariously by witnessing others yelping in pain from certain parts of the field, you can develop your instincts for what is and is not safe to do without really having to think about it.

The instinctive feelings we experience in the pit of our stomachs when we make certain important decisions are, in fact, visceral sensations directly related to subtle emotional memories of the outcomes of similar past choices.

Gut instinct may, at times, literally manifest itself as sensations arising from the gut. When your subconscious decision-making networks spot a great opportunity, or an unpleasant outcome about to repeat itself, the blood vessels of the small intestine contract to restrict blood flow to that part of the body. When the brain has a much more pressing need to deal with, such as being excited or worried about a potentially important, imminent decision, your digestive system becomes a low priority. At these critical moments blood is diverted to your brain to meet its increased demand for oxygen and glucose. In other words the "gut feeling" that you can sometimes feel in your belly are the sensations induced by blood being siphoned away from your stomach to fuel your hungry brain instead.

Butterflies in the stomach

At times we all experience a much more clear-cut feeling of excitement emanating from the midriff when we get "butterflies in the stomach." This fluttering sensation is often *not* greeted with very

(Continued)

much enthusiasm, but it's actually a good sign. It is tangible evidence that your sympathetic nervous system – a branch of the nervous system responsible for getting various organs of the body ready for action – has kicked in to increase your alertness to help you perform at your best. When you are about to do something scary or exciting like delivering a speech or meeting someone you find extremely attractive, you can count on your nervous system to get you all buzzed up and ready to go.

This can all too often be perceived as a negative, but far from it. Any experienced public speaker will tell you that it is actually a positive sign – their performance only *really* sparkles when the butterflies come out to play. The secret is to embrace it. Rather than saying to yourself, "Oh no, I'm so nervous," give those butterflies the greeting they deserve: '"This is great, my body and brain are ready for action – it's showtime!"

Reward line

Human brain imaging has confirmed that a specific brain network swings into action whenever we make any kind of decision – the Reward Line (see Appendix for these brain stops, which are on the Inward-Facing Brain Tube Map). As decision-making involves estimating the potential future reward associated with each possible choice, on the basis of similar past experiences, your Reward Line is the closest thing you've got to a crystal ball. It enables you to predict the future!

The VTA stop (ventral tegmental area) is at the very heart of your decision-making network and is also exquisitely sensitive to any sensory experience that gives us pleasure. It resides in your midbrain, an ancient part of the brain sandwiched between your spinal cord – responsible for sending electrical signals in dense bundles of brain wires to and from your body – and your thalamus. The thalamus is the main biological junction box through which not only all the sensory information must pass on its

way to the crinkly outer cortex, but also millions of neurons that enable different patches of outer cortex to link together.

Quenching thirst with a refreshing drink feels extremely satisfying and that's all thanks to the VTA stop sending a flourish of electrical activity along the Reward Line. Same with eating food when hungry or engaging in some bedroom gymnastics when sexually aroused. What do these all have in common? Eating, drinking and having sex are all vital to the survival of the species.

The pleasure we feel when the VTA lights up acts as an incentive that entices us to go out of our way to find food when we're hungry and water when we're thirsty, so that we can survive long enough to reach sexual maturity. Once our bodies are ready to make babies, the pleasure we derive from having sex is the carrot that makes us want to do it again and again until the pitter-patter of little footsteps eventually come into our lives.

It is important to recognise that the original reason our brains evolved to be able to feel pleasure from these activities in the first place is because they helped us to keep procreating. It was vital to motivate our ancestors to keep passing on their genes and it's also key to ensuring that our species continues to endure the various trials and tribulations that life throws at us from now on.

While other sensory experiences that aren't vital to our survival can also reliably trigger the VTA – chocolate, alcohol and cocaine, for example, have all been given to volunteers in MRI scanners to demonstrate this – it is helpful to remember its original purpose. As the hub of all experiences of pleasure *and* the root of our capacity to anticipate future pleasures, a healthy VTA is absolutely fundamental to all decisions, whether involving matters of life and death or just frivolous fun.

The pleasures derived from receiving a nice gift, admiring a piece of art, listening to music, getting a compliment or sharing a joke all stem from activation of your VTA. This in turn stimulates other parts of your Reward

Line, like the nucleus accumbens, accessed via the ventral striatum (VS stop). This region plays a particularly critical role in decision-making because it is the brain area that keeps track of whether our subconscious predictions of future rewards were accurate or not.

What do you fancy for dinner?

There are five basic steps that your brain must go through during any decision-making process. Let's imagine, ignoring any special dietary requirements you may have, that a friend gives you a call to invite you round for dinner and offers a choice of three dishes.

Step 1. You picture in your mind's eye all the options they mentioned – in this case the choice is between lasagne, veggie curry or sweet-and-sour pork.

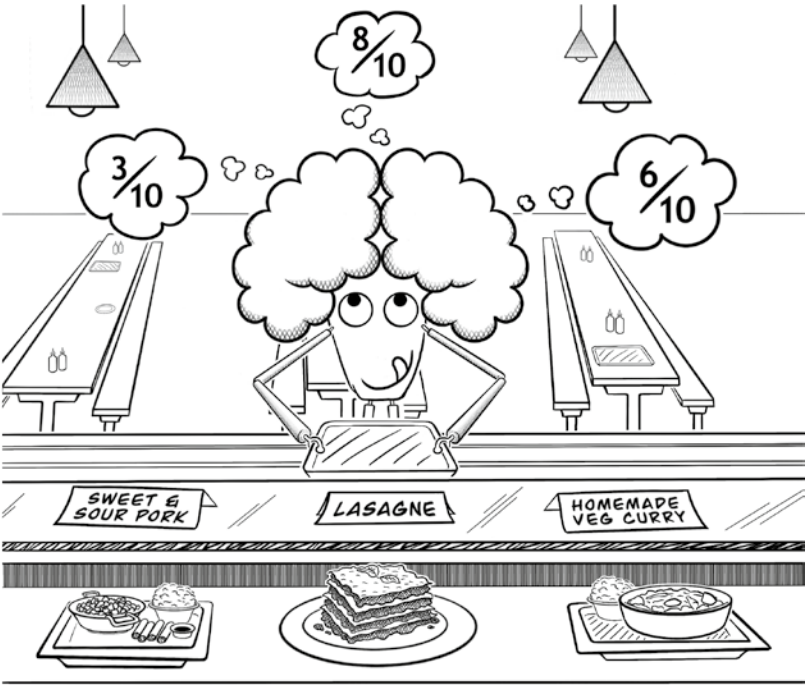
Step 2. Your brain attaches a predicted reward value to each option, a neural mark out of 10, if you like. Of course, you're not consciously aware of what's going on while this system is doing its thing, nor how it's worked out by your brain. The scores are arrived at almost entirely subconsciously based on the strength of the activation in the nucleus accumbens or "buy button." The nucleus accumbens is the part of the ventral striatum most relevant to decision-making.

Generally speaking, neuroscientists hate the "buy button" label because it vastly oversimplifies the computations nucleus accumbens neurons actually perform, but it's easier to say, and remember, so suits our purposes here just fine.

As decision-making relies heavily on previous experience of the available options, the neural score that each option achieves is weighted heavily by how much pleasure was derived from those dishes (or similar ones) in the past, especially the recent past. The buy button signal provides an estimate of how rewarding each option is likely to be if selected again in the future. So, based on your collective experiences

of similar gastronomic choices over the course of your whole life, your brain attempts to predict how much joy is likely to accompany each option, settling on scores of 8 for lasagne, 6 for veggie curry and 3 for the sweet-and-sour.

Under normal circumstances the sweet-and-sour option would have scored a solid 9, rather than the 3 it got today, because usually it is your absolute favourite. However, a recent unpleasant takeaway encounter that kept you up all night has temporarily left you reluctant to go for that option on this particular occasion. The negative experience causes a drastic reduction in the reward value signal produced by the buy button when this option is considered. Were you to be offered the same dish in a year's time, with the sweet-and-sour disaster a distant memory, it might well be marked back up to regain its pole position.



Mere moments before you make your final choice, you recall that you already had pasta for lunch and don't really fancy the same type of dish twice in the same day. So the buy button's predicted reward value for the pasta option is downgraded at the last second from its original predicted reward value activity level of 8 to a 4. This leaves you with the curry option topping the current decision table with a sturdy 6. Despite being a bit boring (it is your default choice as a general rule), at the end of the day you know you'll like it; it's not very exciting but it almost always delivers satisfaction and so it *is* the safest bet. So the final values attached to the choices end up being curry 6, lasagne 4, sweet-and-sour 3.

Step 3. Your brain simply compares these reward predictions. Again this occurs just beneath the surface of your awareness, with the highest-scoring option being the one you "fancy" for dinner. In this case your "gut feeling" would guide you to tell your friend that the veggie curry dinner sounds great.

Steps 4 and 5 are both made after your selection, looking back on the eventual outcome. They are vital to ensuring that the decision-making process continually improves to serve you better and better in the future.

Step 4. You evaluate the outcomes in light of the original prediction – was the veggie curry the best option after all? Or did your friend turn out to be a liability in the kitchen, dishing up a horribly overcooked sludgy mush, so heavily spiced that you needed a whole pint of milk just to get it down? Step 4 is also where the dreaded demon of *food envy* can rear its ugly head. We've all been there, when other people's choices look so much more appetising than our own.

It is at this point that the all-important **Step 5** takes place. Having evaluated the outcome, in light of the original prediction, our decision-making networks are updated for future reference. An *error message* is sent back to the brain areas involved in steps 1–3 to ensure that a better decision is reached next time. For example, this may involve updating future predictions for this option in light of the fact that your friend's home-made "Gujarati veggie curry" is a far cry from the restaurant equivalent.

As our experience accumulates, by the time we reach adulthood we are all experts when it comes to everyday decisions like selecting what we want for dinner. Thanks to vast amounts of experience in getting this decision right or wrong, under circumstances where we always get *quick* feedback on whether our predictions were accurate or not, we don't usually need to invest too much brain power to achieve the goal of biting into a tasty dish on a fairly regular basis. Consequently, we are usually pretty good at predicting which option will yield the greatest gastronomic joy and without too much effort.

Playing classical music in a wine shop increases revenues by encouraging customers, subliminally, to purchase more expensive bottles of wine.

Updating the system

The trouble is, in many other decision-making circumstances, we don't get to see the outcome of our decision until long after we've made the choice, by which time we've often forgotten why we thought it would be a good idea in the first place. This can really muddy the waters when it comes to updating our nucleus accumbens "buy button" estimations of predicted value for next time.

Take choosing a holiday, for example. The time lag between choosing a destination and actually getting to experience it can often be several months. In this circumstance it may be difficult to remember what you were thinking at the time you made the decision, so updating your decision-making process for next time may not go so smoothly. This situation is highly problematic for anyone who wants to stop making the same mistakes over and over again.

Under circumstances where there is a long delay between decision and outcome, people tend not to learn very well from their mistakes.

One of the keys to the success of many high achievers is that, at the time a decision is reached, they keep a note of the main factors influencing their thinking for future reference. Once they know the outcome, if it didn't go well, they can then go back to their notes to work out where they went wrong and which assumptions weren't met.

Of course, nobody enjoys the prospect of looking back on their mistakes, carefully scrutinizing cock-ups and analysing errors, but high-flyers recognize it as an absolute must when it comes to staying ahead of the game. We'd all be well advised to take a leaf out of their book if we want our Reward Line's future predicting abilities to go from strength to strength.

The key thing to remember here is that when you regularly and *quickly* get feedback on the accuracy of your predictions, you can usually depend on your gut instincts to guide you better and better as the years go by. But your gut instinct will probably guide you badly when making decisions that you either make infrequently or frequently but under circumstances where there is a long delay between decision and outcome. These are the types of decisions that benefit from that little bit of extra legwork from your conscious brain – keeping track of exactly where the subconscious reward predictions went well or poorly – if you want to continuously improve the quality of your choices.

"Failure is simply an opportunity to begin again, this time more intelligently."
Henry Ford

The reality is that most of history's super-successful individuals all made a lot more bad decisions than others. That might sound dubious, but that's because we tend to hear more stories about successful people's successes than their early failures. The reason they experience more failures is that they took more risky decisions and then learned from the outcomes. Most importantly, they didn't allow themselves to become disheartened by their early defeats. What really sets them apart is that, having taken on board lessons learnt from past mistakes, they kept their decision-making systems bang up to date for future victories.

Emotion-flavoured decisions

Even *with* a system of conscientious note taking in place, specific memories of most individual decisions will have faded from conscious recollection long ago. Forgotten they may be, but the feelings associated with learning the outcomes of those decisions are usually still with us, safely logged away deep in the memory banks of our brains. They enable the emotions associated with those individual experiences to be subtly retriggered when you find yourself making similar decisions – with the most poignant and the most recent examples being at the very top of the pile.

Emotionally driven

As a professional speaker spending a lot of time travelling, the car I use for running around on business is important to me. I have for many years driven an Audi, my current model being an A4.

These are the criteria that I consciously ran through in my head to arrive at this particular model of car:

1. *Being a family man, I have to be able to fit my wife and children in, as well as myself.*
2. *I'm looking for good performance and reliability.*
3. *I need to be comfortable on long journeys so that I arrive at events feeling reasonably fresh.*
4. *It has to be a car that I feel safe in – my business depends on me being able to deliver.*
5. *I do a horrendous number of miles each year so it really helps if it is economical.*
6. *I didn't want an enormous capital outlay; with my annual mileage it will rapidly depreciate in value.*
7. *It needs to be fairly small to squeeze into tight spaces. Often when I arrive at events these are the only ones left.*

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8. *Image: I inspire people to be successful, so I don't want to be seen turning up in an old banger, but at the same time I don't want them thinking I'm making too much money!*

But why an Audi? After all there are plenty of other good car manufacturers out there that could supply me with a car that fits all my criteria. For years I've wondered why it is I like Audis so much, but I've never been able to give myself a logical answer. That is until a few weeks ago when one of my older brothers happened to mention our dad's favourite old car, an Auto Union DKW – a forerunner of today's Audis. As a boy I loved that car. It was like no other car in the town where we lived and, as a working-class family, we used to feel like kings of the road in it. It was the best car ever! Fond memories came gushing back on being reminded of it.

The emotions are as real now as they were all those years ago. As I write this I can vividly remember the smell of the seats along with the lingering blue smoke from its two-stroke engine! Now I know the true underlying motive that drives my preference for the Audi brand. My love of Audi may well be based purely on an autobiographical, emotionally rich childhood memory, but it's been happily justified for decades with my "reasonable" and "logical" list.

– Adrian

If we really wanted to understand why our brain is urging us to make one choice over another we may, in many instances, have to work back until we arrive at an emotionally evocative experience that happened long ago. At the time it might not have seemed like an experience of note, but it may still have given birth to a deep-rooted belief, a belief that always generates the same emotional bias whenever we think of it.

Push and pull

When it comes to emotional biases, our more difficult choices are often finely balanced. We are drawn by a very subtle emotional *pull* towards options similar to those that resulted in positive outcomes in the past and a gentle emotional *push* away from those that resulted in a negative one.

We've already heard that the *pull* is generated by a strong signal from the buy button. The *push* can be caused by various factors, such as the discomfort we feel when faced with a hefty price tag. That particular signal is created in an island of brain tissue known as the anterior insula (ant Ins stop) – a stop on the Taste Line buried deep in the valley between the Temporal and Frontal districts. A different form of *push* instinct sets warning bells ringing in your amygdala (on the Limbic Line) when you worry that a choice is simply too risky.

Alarm activated

Alarm bells can be set off by the slightest of things. If a yoghurt is described as "90% fat free," no alarm is triggered because at first glance, that looks like a high proportion of a good thing. But had the same facts simply been described differently as "10% fat" then – *ding, ding, ding*! That looks like a small but significant amount of a bad thing.

This phenomenon is known as "framing." You can describe any set of options in different ways to dramatically shift people's choices. It revolves around whether the options are described in a way that draws attention to the positives or the negatives. Both "90% fat free" and "10% fat" mean the same thing, but they trigger a response in slightly different brain systems. While the positive perspective stimulates your Reward Line, the negative perspective stimulates the amygdala.

Overall this system of push and pull has served us surprisingly well over many years. It is clumsy in certain circumstances, but overall highly effective in matters of staying alive. Even in this day and age when survival is relatively straightforward (in most parts of the developed world, at least), it operates perfectly well in most everyday decision-making scenarios.

Our instincts can be trusted even when making very complex decisions. When there's an overwhelming amount of information to consider, following our instincts *can* lead to good decisions, but only if we first invest the time to gather together and carefully consider all the relevant facts. The secret is to postpone the final decision until you're really ready. First you have to find time to do your research properly, consult the experts, compare notes with other people who've got more experience than you and then sleep on it for a couple more nights to give your subconscious a chance to stir the pot. Only make the final decision, which will still be based on your gut feelings, once your brain has had a chance to process all the fine details. The less frequently you've made such decisions in the past, the more research you need to do and the longer you need to let it marinate in your subconscious before finally taking the plunge.

Danger zone: excessive buy button activity likely

Anything that makes us feel excited tends to drastically increase activity on the Reward Line, bringing us closer to giving into temptation and throwing caution to the wind. Danger zones are entered when activity on the Reward Line is seriously ramped up by exciting sales environments: the big, bright, bold signs advertising amazing savings or the loud music and flashing lights of a lively bar. Even attractive and charismatic staff help to drive sales by throwing our Reward Line into a frenzy – leaving us prone to spend more than we ever intended.

In such circumstances, the desire for instant gratification will prove almost irresistible and any long-term plans of saving for a new car or summer holiday go straight down the drain.

"The chief cause of failure and unhappiness is trading what you want most for what you want right now"
Zig Ziglar

A similar scenario has fouled many a determined plan to lose weight. When in a restaurant, having stimulated the Reward Line with good food, a few drinks and pleasant company, diets often go right out the window. We eat 25% more food when dining with one other person, 39% more when dining as a threesome and a whopping 79% more when eating with three others! All it takes is one person to ask for the dessert menu and it's goodbye healthy eating regime.

Losses loom larger than gains

Brain scanning experiments have revealed that activation levels in our favourite part of the decision-making apparatus – the nucleus accumbens or "buy button" – not only increase in response to a positive outcome, but also decreases when an expected gain doesn't come our way. Worse still, if the person suffers an unexpected loss, the buy button activity levels flatline completely.

The most important thing to take into account here is that losses result in much larger reduction of activity than gains of exactly the same size increase activity. In other words, your Reward Line disproportionately overreacts to losses in comparison to gains, a neural explanation for why we can find ourselves "once bitten, twice shy."

This helps to explain why we humans are, on the whole, so extraordinarily loss averse. Most people won't accept a gamble unless the potential gain is at least twice the size of the potential loss. Hence the minimum return in most casinos is double or nothing.

Your buy button is also hyper-responsive to unexpected gains, but this time in a positive direction. You can use this Power of Surprise Rewards to your advantage. If you give someone a gift in circumstances where the recipient has a fair idea what the present is likely to be (and when they are likely to receive it) – like getting yet another bunch of wilting flowers from the local petrol station on Valentine's Day – only a small increase in activity will be triggered in the reward pathway. This corresponds to the recipient feeling "quite" happy, but hardly overwhelmed. Not great, but far better than a fully expectant person not receiving anything at all, which would result in a rapid deactivation of the reward pathway and a corresponding crushing sense of disappointment.

If there's an element of surprise in the gift-giving scenario, however, then that exact same gift can induce a completely different response in the recipient's brain. If flowers are received completely out of the blue, for

example, then there will be a disproportionately large response on the Reward Line and a surge in happiness to match it; usually resulting in a rather large haul of brownie points!

Giving really is its own reward

When people lose money, activity on the Reward Line usually drops like a stone. But if that money is donated to a charity you care about, activity on the Reward Line actually shoots up! Giving to a worthy cause cancels out any bad feelings associated with a financial loss, replacing it instead with a warm altruistic glow. The Reward Line is wired to enjoy helping others.

To help you make better decisions, the Reward Line is constantly adjusting your brain's blueprint of what is likely to happen in each environment you regularly spend time in, at different times of day, on any given day of the week. These expectations are forever being updated, undergoing tweaks and adjustments to improve their accuracy, according to the feedback you get from your daily experience. The more an event deviates from the expectations in this blueprint, the more powerfully the responses on the Reward Line are tweaked up or down. And the more surprising the occurrence, the more emotional flavour is given to its memory, making it easier to recall for next time.

The price of impatience

If you were offered the choice of £100 today or £110 this time next week, which would you go for? Many studies have shown that the vast majority of us would choose to take the £100. Over and over again our love of instant rewards (and distaste for uncertainty) has proven to motivate people to accept rewards of lesser value, so long as they're received sooner rather than later. And why not?! We all know that a lot can change

in a week: the offer might be withdrawn for some reason, the person making the offer might disappear or it might be us – the expectant recipient – who can't make the appointment when the time comes.

Who knows what's around the corner?! The problem with this tendency is that many of life's most important decisions, often boring things like saving enough for retirement, require that the all-powerful lure of immediate gratification be actively subdued in favour of more profitable long-term goals.

Marshmallow test

A classic experiment carried out with four-year-old children makes a strong argument for the benefits of resisting temptation in the short term, when it comes to getting better outcomes in the long run.

Each child was sat in front of a plate bearing a single marshmallow or some other tasty sweet treat. The task was simple: wait a few minutes while the adult left the room and, if the child was able to resist the temptation to eat the treat, when the adult returned they got two tasty treats instead of one. Some kids, as you might have guessed, just couldn't resist and gobbled up the delicious treat as soon as the adult departed. Others demonstrated incredible resolve and, despite clearly being tempted, managed to hold off to claim the bigger reward.

This simple experiment had some profound implications. These same children were tracked for over 20 years. It turned out that those who *could* rein in the impulses generated in their Reward Line, resisting the lure of immediate gratification, went on to greater successes compared to those who couldn't. They went on to get better grades at school, get better jobs and ultimately enjoy higher earnings throughout their careers.

The kids who *couldn't* resist the urge usually stared temptation in the face, gazing lovingly at the enticing sweet treat, sometimes giving it a cheeky lick, before giving in and popping it in their mouth. Those who *could* resist the urge usually tried to divert their attention away. Some kids turned sideways and looked at pictures on the wall. Others shut their eyes and sang themselves a little song.

The kids who did better in life showed an instinctive awareness that scrutinising the temptation would only make resisting it harder and so they instead found ways to distract themselves. One little girl used her imagination to neutralise the threat by singing to herself: "You're not a real marshmallow anyway, you're just a floaty pink cloud!"

Given what you now know about sensory perception, it seems that many of the kids destined for success invented strategies that altered the "top-down" processing of the sensory information arriving in their brains. They found clever ways to make it easier to successfully resist temptation and to maximise their overall long-term reward. We can all learn from this.

All of us can learn to control our impulses better. We just need to use a little imagination to find ways that help us to reduce the levels of excitement in our Reward Lines when confronted with the enticement of instantly gratifying treats.

It is also important to bear in mind that our capacity to make disciplined decisions, those that make sense in the long run as opposed to merely solving a problem in the short term, gets weaker and weaker as the day progresses. As each and every decision takes its toll, we usually start running out of steam towards the end of the day. And when this happens we're more vulnerable to the lure of taking shortcuts and acting on impulse. This is why important decisions should be made earlier in the day when we're still fresh, not right at the end of the day when we're tired and getting impatient. For this reason, many of the world's most

successful people – leaders of nations and businesses alike – take decisive steps to minimise their need to make *any* unnecessary decisions. What they wear, how they get around and even the food they eat for breakfast has all been decided in advance to free up precious brain resources for the most important choices. Could you do something similar?

Chapter takeaways

- Your brain operates a neural scoreboard of likely outcome predictions based on recent and peak past experiences; this occurs almost entirely on a subconscious basis.

- Logical reasoning often justifies our emotional choice retrospectively. Identify past experiences that might make you feel that way – are they still relevant now?

- Trust your instincts in circumstances where you have extensive experience of similar decisions, carefully ensuring you delay the final decision until you're *not* in an overexcited state of mind.

- Distrust your "gut feelings" in circumstances where you have little experience or when a certain choice gives you a small quick win over a larger long-term reward.

- Develop your skills of resisting the urge for immediate gratification; practice gradually strengthens this ability over the course of weeks and months.

- Make important decisions at the beginning, not the end of the day. Buy time – but don't postpone forever. Research, consider, discuss with those more experienced than you, mull it over, *then* go for it!

Food for Thought

Don't wait for the leptin

Your 100-million-neuron "Enteric" nervous system is affectionately referred to as the "Gut Brain" and is primarily responsible for regulating digestion. It uses its own autonomous system of neuronal circuitry running along the entire length of the gut to check out what kind of foods you've been stuffing yourself with, sending in appropriate squirts of digestive enzymes, coordinating the timing of the rhythmical, muscular contractions to keep everything moving along at just the right pace to maximise extraction of nutrients from the foods you eat and neutralise any nasty microorganisms that might be hitching a ride.

While your Gut Brain can do all of this without any help from Brain HQ if it needs to, it does keep headquarters fully informed about what it is up to. Electrical messages are sent to and from your brain via a large bundle of neurons called the Vagus Nerve. Your gut even has its own set of appetite-regulating hormones that are released into the bloodstream so that they can flick molecular switches in your brain, toggling the hunger centres on and off according to whether your digestive system is empty or full.

Ghrelin is the name of a hormone released from your stomach when it's empty. It travels up to your brain's Hypothalamus to produce feelings of hunger, motivating you to find food and eat it. Having eaten, when food starts moving from your stomach into your small intestine, another hormone is released, cholecystokinin (CCK), along with leptin, produced by cells that store excess calories as fat. Leptin and CCK have the exact opposite influence to ghrelin. They make you feel full up and temporarily switch *off* your desire to eat.

An important aspect of this system of chemical communication is the all-important time lag between *being* full and *feeling* full. It takes a full 15–20 minutes after food firsts starts expanding your stomach before hormonal signals reaching your brain eventually trigger feelings of being satisfied. This delay is the reason so many people carry on eating long after they've consumed a perfectly sufficient amount of food.

Back in the days of our ancestors, when getting enough food was a daily struggle, this helped us tuck away storage fat under our skin so that we could survive the inevitable periods where food was temporarily unavailable. These days, however, with plenty of food around 24/7, all it does is make us consume more calories than we are ever likely to burn. So what was once a brilliant design *feature* back in the distant past, these days is starting to look more like a design *fault*. Not ideal for the waistline, but more importantly, not a great idea if you really want your brain to operate at the best of its potential.

By the time we stop eating we often feel overstuffed. This bloated feeling has a big effect on our mood and motivation levels. As well as feeling sluggish and lethargic, we can feel a little disappointed with ourselves because, despite having overindulged on so many other previous occasions, we've gone and done it again! That said, once your Brain HQ gets a fuller understanding of how your Gut Brain functions, you'll start to think differently about what, when and how much food you choose to eat each day.

Eat like an Okinawan

There are a few places in the world where a greater proportion of people live to be over 100 years old than anywhere else. One of these is the Japanese island of Okinawa. As you can imagine, many researchers have tried to unlock the secrets of why Okinawans enjoy such long lives.

The traditional diet consists of small amounts of meat every now and again, but with lots of fish and low-calorie, nutrient-packed fruits, berries, seaweeds and staple vegetables like sweet potato. Oily fish is packed with omega oils (aka polyunsaturated fatty acids, or PUFAs), which are extremely good for brain health because they play a vital role in keeping neurons flexible.

When overweight human guinea pigs switched to an Okinawan diet, the men lost 18% of their body weight and the women 10%. As a result, their blood pressure was significantly reduced, as was the overproduction of insulin and bad cholesterol that they'd been struggling with.

A big clue to Okinawan longevity could lie in their dinner time mantra: *Hara hachi bu,* which roughly translates as "Eat until you are 80% full."

The idea is, if you don't overburden your digestive system on a daily basis, then all your organs are put under less duress *and* fewer substances that pose a long-term health risk get a chance to accumulate in body and brain.

Tip 1: In one sitting, never eat more food than you would be able to hold in your two hands cupped together. The exception to this is foods like a leafy salad, in which case, make it double: two cupped hands!

Tip 2: If you tend to eat too much on a regular basis, here's a simple solution: get rid of all your old crockery and replace it with smaller plates and bowls. It may sound extreme, but smaller plates encourage the dishing up of smaller portions and can drastically reduce overeating.

Eating for two (kilos of gut bacteria)

It is no exaggeration to say that over the past few years there has been something of a revolution in our understanding of digestive biology. Who'd have thought, for example, that a bunch of bacteria in your gut could influence your mood? Incredibly, the single-celled organisms quietly residing in your intestines outnumber the cells that make up your *entire body* by a ratio of ten to one!

It's been known for some time that these passengers – who've been hitching a ride in your gut your entire life – are helpful for the digestive process. For example, we've known for a while now that gut bacteria eat the fibre that we ourselves can't digest and use it to produce a substance that makes us feel fuller faster. There's more fibre in brown bread than white bread, brown rice than white rice, brown pasta than white pasta and so on. To feel fuller quicker – all thanks to your gut bacteria – you just need to eat the unrefined versions with the fibre left in.

Evidence that the "good" bacteria can also powerfully influence something as seemingly unrelated as your mental health, however, is a much more recent revelation. It turns out that when we choose what we want to have for breakfast, lunch and dinner, we should be thinking about what's best, not just our hearts and brains, but also the trillions of helpful bacteria living in our intestines!

The question is: how in the world could microscopic creatures in your gut possibly have a meaningful impact on your brain? Well, for one thing, some of the populations that make up the 100 trillion gut microbes inside you increase the amount of energy that can be extracted from certain foods – influencing how energised you feel. Others actually manufacture essential vitamins from the food in your intestines so that your brain can use them as special building blocks to create various essential neuronal structures and brain messaging molecules.

Vitamins for breakfast

Boiled eggs with Marmite soldiers might not sound like a superfood combo, but it most definitely is! Eggs are jam-packed with choline, which brains use to create the neurotransmitter acetylcholine in the hippocampus (DG and EC stops) and elsewhere. Marmite (or Vegemite for our antipodean cousins down under) is an incredibly rich source of B vitamins, which help to release energy from foods. B vitamins have to be eaten every single day because, being water soluble, they can't be stored in the body. Vitamins A, C and E, on the other hand, are fat soluble, so you *can* store them (in your body fat), but only for a couple of days. That's why it's so important to eat fresh fruit and veg daily!

This exciting new area of research is only just getting out of the starting blocks. One study found that when healthy human volunteers were given a 30-day course of "good bacteria," consisting of a mix of two different

probiotic bacteria (namely *Lactobacillus helveticus* and *Bifidobacterium longum*), it led to a decrease in feelings of depression and anxiety. Each of the different types of bacteria in probiotic yoghurts perform a slightly different useful task in keeping brains happy and healthy, so it makes sense to choose those that list more than one type if you want to get more bang for your buck.

A recent study used brain imaging to investigate the impact of gut bacteria on brain function. It found that people regularly fed a yoghurt drink packed with probiotics, compared to those who drank the same yoghurt but without additional good bacteria, had significant reductions in the responsiveness of the Amygdala stop when they were shown emotionally disturbing images. It's early days, but the balance of evidence so far seems to point to certain gut bacteria having a significant influence on our capacity to effectively manage our emotions, by reducing our "emotional reactivity."

Gut bacteria are responsible for manufacturing 95% of all the body and brain's serotonin – a neurotransmitter as vital for mood stability and good sleeping patterns as it is for a healthy gut. Gut bacteria also produce several other neurotransmitters – chemicals involved in communication across the synapse – including acetyl choline, dopamine, melatonin, GABA and noradrenaline. You'd be forgiven for assuming that the influence of gut bacteria on your brain comes down to the chemicals they produce moving on up to the brain via the bloodstream. But it's not quite as simple as that.

What does and doesn't gain entry to the brain is tightly regulated by a protective wrapping around the brain's blood vessels called the "blood brain barrier." It seems that the main route of communication from gut to brain in terms of mood manouevres is actually via the Vagus Nerve. This meandering cluster of wire-like neurons connects the brain to many different organs, including the lungs, heart, liver and gut, enabling them to switch between "action stations" or "rest and digest" mode, depending on what you're up to from one moment to the next.

In experiments with stressed rats, cutting the Vagus Nerve prevented their unbalanced gut bacteria from negatively influencing the brain. Their emotional behaviours, pain perception and stress responses all returned to normal. Vagus Nerve stimulation is even an option for treating chronic depression in humans.

Prebiotics versus probiotics

Probiotics are the good bacteria themselves. There are many "probiotic" foods in the supermarket that you should try to eat on a *daily* basis, to reinforce the armies of "good" bacteria in their perpetual battle for gut territory against the "bad" bacteria. But that doesn't mean having to buy expensive foods. All natural yoghurts and many cheeses have "good" bacteria in them, as do partly fermented foods like fresh sauerkraut, kimchi and kombucha.

Prebiotics are simply foods that the "good" bacteria like to eat, stuff that we can't digest ourselves like fibre – plentiful in whole grains, broccoli, beans, leafy greens and all fruits – one of the foods probiotics love to munch on. Other prebiotic-rich foods include asparagus, artichokes, garlic and onions, plus a trio that makes for a great set-piece breakfast: milk, oats and banana. Extra-special prebiotics include mushrooms (for the beta-glucans) and aloe vera juice (for the glucomannans). It may sound a bit odd, but if we want to feel energised and ready for anything, we should balance what we *want* to eat against what our good gut passengers *need*.

Regardless of the precise mechanisms by which the gut bacteria influence brain function, they are something you should give serious consideration to. If you're feeling irritable, stressed or on a bit of a downer, you may wish to tip the balance in favour of your gut's "good" bacteria by providing reinforcements in the form of a daily probiotic yoghurt drink *and* foods that your passengers thrive on.

Equally and oppositely, it's best to take antibiotics only when the medical need to do so is pressing. That's because antibiotics are indiscriminate. They wipe out all bacteria in the gut, both good and bad. Pressuring your doctor for antibiotics whenever you feel ill is a terrible idea, for several reasons. But if you really do have to take antibiotics to knock out a nasty infection, make sure you take steps to help your good bacteria regain their strength once you're better. That means eating probiotic-rich foods. Otherwise the residual bad bacteria might gain the upper hand and end up colonising all the best nooks and crannies.

The balance between health-promoting good bacteria versus the disease-causing bad bacteria can also be tipped by stress. Changes in the balance of good versus bad gut bacteria have been found to affect physical health, emotional state and pain perception, so when people do manage to reduce their stress levels, the improvements they notice in their overall well-being may come down to a better blend of gut bacteria. Strange, but true!

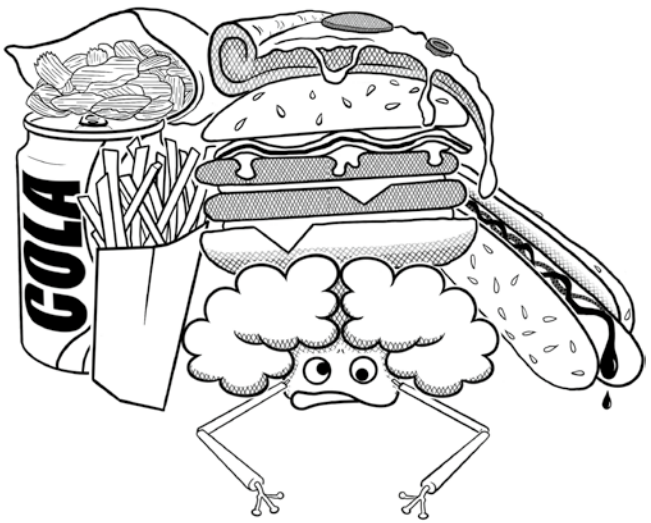
Fat filled and sugared up

Let's take a look at the fuel that we should be putting into our brains to help them work better; the last thing we want to be doing is putting diesel into a petrol engine.

Although your brain weighs only 2% of your overall body weight, it consumes up to 20% of all the oxygen and sugar available in your bloodstream and that's just when it is ticking over quietly. When working flat out, such as when you're really concentrating hard on something, the brain's demand for energy resources from your blood shoots up to 50%.

Part of the reason you feel the urge to snack while deeply focused is because your brain is using up so much energy. What you choose to put into your mouth to try and meet these demands plays a critical role in how well it will function for you as the day unfolds, not to mention the potential impact on your waistline.

Most modern humans have a distinct weakness for snacking on foods made almost completely from sugar and fat. These irresistible, beautifully packaged sources of pure energy often feel like they are providing you – the consumer – with a perfectly satisfying, instant fix. The truth is, as far as brains are concerned, all those quick fixes add up to nothing short of a nightmare.



The reason people love the sugar- and fat-loaded processed foods so much is that we humans evolved, over many millennia, to find high-calorie food options delicious. In the past, such treats were rare and important to our continued survival because, until recently, death through starvation was a very real possibility. When starvation *is* an imminent threat, it really pays – in terms of survival – to eat calorie-rich foods that are high in sugar and fat, as all the excess can be put into storage throughout your body for use when food is scarce.

In today's developed world, however, the situation is very different. Supermarkets are jammed to the rafters with food. And so for most of us, the primary threat to our health and well-being is not starvation but

overindulgence, in food and drinks that are always at hand and usually high in fat, sugar or both.

Shelf life reduces health life

The reason that processed snack foods last for so long is because the nutrients – the parts that are good for you but also responsible for making foods go off – are stripped out. Taking out the nourishing raw materials leaves you with a food that tastes of cardboard, so to make it taste good again loads of sugar, fat and salt are added. Worst of all, when trans fats are added into the mix – to improve the texture and "mouth feel" that makes pies crusty, biscuits crunchy and cakes springy – they also clog up all your body's arteries like nobody's business.

Fast food outlets, kiosks and vending machines continue to pop up all over the place to keep these temptations forever in our midst, ensuring that these tantalising treats look and smell as appealing and alluring as possible, in an effort to make them almost impossible to resist. Strategically placed, brightly lit, the whole spectacle is carefully designed with temptation in mind, to draw in peckish passersby with their soft spot for immediate reward like moths to light.

More often than not the companies that make these delicious but dangerous products are huge multinational corporations that know only too well how irresistible and addictive their goodies are, especially for those on the move, in a hurry, or just plain bored. These days it's an around-the-clock snack fest out there with impulse-buy fixes available almost anywhere and at any time.

Sadly, there is good evidence to suggest that companies have started to specifically target younger and younger children in the hope of building a highly profitable sugarholic generation, using marketing strategies to encourage bad snack habits at the earliest possible age. That break-time

fizzy drink and a packet of crisps later on in life becomes a well-deserved biscuit with our coffee for "elevenses," a midafternoon chocolate bar, an after-dinner dessert and a ready-sweetened, fat-saturated bedtime drink to round off another calorie-packed day.

The good news is that raising awareness about fat cats who get richer by training us up from youth to consume as many calories as possible may help people to resist the sweet and fatty stuff more often. The outrage that young people feel when they fully understand the ugly tactics used to boost profits by intentionally fuelling the global obesity pandemic inspire them to say "no!" to the daily habit of grazing on processed foods. They don't ditch it entirely, just eat it less often.

Sugar-coated vandalism

For most, snack habits develop not necessarily because people are weak-willed or gluttonous, but because it all seems so harmless. In the 1950s and 1960s smoking seemed harmless. Everyone had an old aunt or uncle that they could point to who, despite smoking a hundred cigarettes per day, were still going strong. It seemed like everyone was at it and they weren't dropping dead, were they?

Well, yes they were – but it wasn't obvious to the general public what actually caused the premature deaths of the vast majority of smokers. Doctors, however, had noticed that smokers seemed to die early and, in more cases than not, from the same set of diseases. By the 1970s and 1980s the evidence that smoking caused a variety of cancers became overwhelming.

Sweets, fry-ups and cakes might not give you lung cancer, but high-sugar, high-fat diets are killing people nonetheless! Here's why.

When you eat or drink foods high in sugar – for example, sweetened or alcoholic drinks, chocolate bars and cakes – all that freely available sugar gets dumped straight into your bloodstream, quickly ramping up

to potentially damagingly high concentrations. As any diabetic will tell you, high sugar levels are bad news.

From a brain's point of view, too much sugar is a big no-no. You see, in too big a quantity it really does mess things up. It is no exaggeration to say that it quite literally vandalizes your brain's lines of communication with your body. If you want to see how this happens with your own eyes, go and make a meringue.

The special wrapper (called a myelin sheath) that helps your nerve fibres to carry messages from your brain to your body (and from your body to your brain) at lightning speeds is made almost entirely from special fats and proteins. In meringue making, when you add sugar to egg whites a chemical reaction occurs that turns all that soft, gloopy, transparent protein into hard, white, chalky meringue. Delicious when served with a dollop of whipped cream, but not so great when the sugar has made a damaging meringue out of your brain wires!

In order to avoid the catastrophic consequences of having all your brain wires turned into useless strands of meringue, your body releases insulin. Insulin is a fiendishly clever hormone that reduces the concentration of sugars in your bloodstream. It does this by transporting the sugars out of the blood and into the surrounding tissues. In the first instance this excess of sugars gets converted into glycogen, then stored in your liver and muscles for later use.

No vacancies

All well and good so far, but when the "no vacancies" sign goes up (in other words, there's nowhere left to store glycogen), then that's when things can start to go pear-shaped, quite literally! Running out of options and desperate to find a home, glucose starts getting converted into

fatty deposits, seeking refuge under your skin. Not, as you can imagine, the most attractive thing to happen, but nowhere near as dangerous as what accompanies this process deep within your body. Fatty deposits start getting stuffed in all around your vital organs. Now that, without overstating it, is *really* bad news.

So, if you've started to notice a few wobbly bits on the outside of your body, there will also be a whole host of blobby accumulations deep inside that may well be throttling all your organs! The good news is this: if you're hitting the gym and not seeing the results you wanted on the surface – the fat under the skin being notoriously stubborn in sticking around – don't lose faith. Thanks to studies using MRI (to scan the body rather than the brain) we know that the main threat to your health – the fat surrounding your internal organs – is the first to be shed.

What this all boils down to is that if you are a serial snacker, all the excess sugar you snack on is converted to fat. That's because for most people in the developed world, our glycogen stores are almost always full because we regularly top up our sugar levels out of habit, usually well before the hunger has really kicked in.

On top of all this, eating fast-release sugar snacks stimulates an all-too-sudden release of insulin. This dramatic hormonal release causes tissues to overcompensate – removing too much sugary glucose – which is why you usually feel depleted again a short while later.

This is great news for the companies who make these snacks; they *want* you to eat as much of it as humanly possible, regardless of the net impact on your health, to keep their profits climbing. There's a simple rule that they know only too well: if you are regularly producing huge squirts of insulin – as a direct result of eating large quantities of sugary carbs – you'll soon be running low on sugar again and looking for something to munch on. Ker-ching!

Sugar rush: no myth

A sugar rush does indeed make you feel good, but it's less to do with the impact of the excessive sugar itself and more to do with the large dose of insulin released from your pancreas into your bloodstream to deal with it. Insulin is released to remove the excess sugar to help avoid a whole range of unpleasant health problems and even death.

But insulin doesn't just extract sugar from your blood. It also takes out the amino acids, the building blocks of all proteins. All the amino acids, that is, apart from one that is extremely important to your brain – tryptophan.

Tryptophan (pronounced: trip-toe-fan) is the basic essential building block for a variety of neurotransmitters. One of these is called dopamine, the vital neurotransmitter manufactured at the VTA stop of the Reward Line, which as you know plays an important role in triggering feelings of happiness and making decisions.

Under normal circumstances tryptophan has to compete with all the other nineteen different types of amino acids, queuing up at the tightly controlled entry points to your brain across the blood-brain barrier. With insulin sucking all the competing amino acids out of the queue, the tryptophan can easily gain access to your brain with fast-pass access. The higher than usual availability of tryptophan leads to greater amounts of dopamine (and serotonin), explaining why a sugar binge feels so good.

This might be an effective way of making yourself feel good in the short term, but in the long run this has the potential to ruin your health. In the medium term, sugar binges slowly but surely make you fatter because all that excess sugar continues to be

converted into fat. Worse still, after a lifetime of asking too much of your insulin-blood-glucose regulation system, the long-term prognosis is Type 2 diabetes, along with a whole range of spin-off health problems affecting the heart and blood vessels.

Best brain fuels

Avoid fast-release sugars as much as possible and instead eat foods that release sugars slowly but surely into your bloodstream. This is the best way to avoid the "sugar roller coaster" – alternating periods of rocketing and plummeting blood sugar levels that lead to high energy, manic behaviour one minute, quickly followed by low energy, low motivation and irritability a short while later.

Slow-release carbohydrates like whole oats and other whole grains (meaning "unprocessed" grains), sweet potato, leafy greens, orange, yellow and red vegetables, not to mention most fruits – all release sugars into the bloodstream *gradually*, helping you to avoid the perpetual ups and downs of a diet heavy in fast-release sugary carbs. Different types of vitamins and minerals are what give the fruits and veg their colour, so a multicoloured plate of these sources of fresh, slow-release carbs is your best bet. Such foods are also full of fibre to feed your hungry gut bacteria. The slower release of sugars into the bloodstream, necessitated by the gut needing time to break these foods down to set the glucose free, means your blood sugar levels don't get high enough to trigger an emergency dose of insulin.

A good strategy is to have unprocessed porridge oats for breakfast (for the slowly released sugars) that keep you going until lunchtime, perhaps topped with apple, pear, banana or berries with a drizzle of honey (to give you a bit of a jump start, natural sugar, energy boost). Commercial cereals boasting "added vitamins" fall

(Continued)

into the category of processed foods – the natural nutrients are stripped out and replaced with fat, sugar and salt – to which industrially manufactured vitamins are added that your body simply can't absorb half as well as when natural vitamins are consumed in fresh foods.

When the urge to nibble does become irresistible, drink water and eat fruit; raw vegetables dipped in hummus; nuts like almonds, walnuts and pistachios; or wholegrain snack bars. Bear in mind that being in a hungry state, with all that ghrelin swirling around in your brain, biases decisions towards immediate gratification. Healthy snacking can take the edge off the hunger and fuel you up before any big decisions, *without* setting you off on the sugar roller coaster.

Deciding what to eat when very hungry, versus a "bit peckish," has a big impact on how much food you'll put on your plate, for example. Not being so hungry at lunchtime and thus less likely to overeat will help you to avoid ending up carrying around a food baby all afternoon. Food babies, like all babies, need looking after. Not only do they make you feel completely stuffed; they also make your brain operate sluggishly due to all the blood being diverted to your gut instead.

If you want to stay on the ball, slow-release carbohydrate snacking is the way to go. When you come to choose your lunch, there'll still be some glucose knocking around in your bloodstream to fuel certain important brain areas in and around the dlPFC stop that help us make more disciplined decisions. This is the critical brain area that enables us to favour whatever gives us the best reward in the long run over the immediately gratifying options.

Instead of going from being positively buzzing one moment and then feeling lethargic, unable to focus and getting all irritable the next – occasional snacking on slow-release carbohydrates ensures that your energy levels are on a more even keel. Throughout the day, you'll probably feel a lot happier with yourself, your mood swings won't be so

dramatic and those around you will probably also benefit from your newfound slow-release carbohydrate diet too!

Three quick points

1. Sugary snacks do have their place; you just need to use them sparingly and strategically, rather than habitually. Prior to a big performance it doesn't hurt to eat something packed with fast-release sugars, because you know you're going to use them up. This is because the adrenaline release triggered by standing up in front of other people increases your metabolism, releasing extra energy in your brain and using up that extra sugar, to keep you on top of your game.
2. Healthy snacks are only healthy when eaten in moderation. Just because they are "healthy" doesn't mean that you can gorge yourself on them nonstop! Not to mention that many cereal bars have more calories in them than a bar of chocolate. So be careful in the supermarket – compare the sugar and fat content to your favourite bar of confectionary to make sure you're not being suckered. When you do find the genuinely healthy ones, don't eat more than one!
3. Go bananas! Bananas are the perfect on-the-go snack. Among other things, they're loaded with natural quick-release sugars, dripping with zinc (which helps to release energy from the sugars), packed with tryptophan, high in fibre and even come ready wrapped!

The importance of when, not just what, you eat

Many people panic a little bit when they hear a rumble in their belly. The thought process usually goes along the lines of: "Oh no, I must be starving; better eat something pronto!" But is it really something to

be concerned about? *Starving* is hardly an appropriate way to describe this, given the abundant stores of energy in our bodies. And what is that funny gurgling sound all about, anyway?

A rumbling belly, far from being a cause for concern, is actually great news! It means you've managed to give your gut a break from all the hard work it does dealing with all that food and drink you consume. It has finally found an opportunity to get out the hose and give your digestive tubing a bit of a jet-wash.

A rumbling *stomach* is actually the sound of the *small intestine* swabbing the decks so that they're all sparkly and clean, in preparation for the arrival of the next load of food. This can only happen when several hours have passed since your last bite to eat. The reason it is important to give your gut a break from all the hard work, every day, is so that it can get some repair and maintenance done. Better still, if you can get all of your day's eating done in a narrow time window, the time it spends ensuring that everything's in good working order is maximised.

Oiling the brain cogs

What's the big deal with olive oil? Is it really so great for brain health? Certain vegetable oils like olive oil, hemp oil and canola oil are examples of mono-unsaturated fats and help to keep your brain fit as a fiddle. They are so good for you that you can drink a teaspoon every day! Frying food in olive oil, on the other hand, is not such a great idea. It burns at a relatively low temperature, turning a health food into a nightmare. Better to fry food in oils that can handle the heat. Just slosh some extra virgin olive oil onto your food straight from the bottle and you'll be in business.

Fasting, as you are no doubt aware, means not eating. Whether or not you realise it, we *all* fast every day. Well, to be more accurate, every night. Some of us fast only for a very short while in any given 24-hour period,

munching away from the moment we wake up until the moment we hit the sack. Others leave a longer pause between the last and first eating session on consecutive days. But one thing that we all share is that nobody eats when they are fast asleep.

Better still, not eating requires *zero willpower* when we're safely tucked up in bed, exploring the land of nod. As we all get an overnight fast for free, we have an opportunity to lengthen the duration of this fast, little by little, day by day, so that eventually our fat-burning metabolism gets a chance to kick in more readily. This happens when our body and brain has gobbled up all the glucose in the bloodstream *and* has released all the glucose from our glycogen stores. That's when your body has no other option but to start tapping into the fat stores – both under your skin and around your organs – if it wants to release some precious energy to keep your brain ticking over, via a process called ketosis.

Your glycogen stores last for about 10–14 hours after your last bite of food or sip of a drink. (Water and herbal teas don't count because they contain no sugars; milk, on the other hand does, even a tiny splosh in your tea!). You'll switch to fat-burning 10 hours after your last morsel of food or drink if you do a lot of exercise, after 14 hours if you don't. So as a rule of thumb, if you can manage 12-plus hours between eating your last morsel of food (or sugary drink) at night and the first thing you eat the following day (when you "break" your "fast"), then you will be spending at least *some* time each day in fat-burning mode.

The best way to get all the benefits of *time-restricted feeding* is to stop eating completely in the late afternoon or early evening. The benefits include not only keeping obesity, heart disease, diabetes, cancer and lots of other potentially nasty health problems at bay, but this also encourages the birth of brand-new neurons and synapses in your hippocampus, upgrading your memory banks.

The most important thing is to avoid eating right up until bedtime. That is well known to put all sort of metabolic processes out of whack and inevitably leads to weight gain. That said, many people find it much easier to curb their desire to eat naughty-but-nice foods in the morning

compared to the evening. So if stopping consuming any calories after, say, 7 pm just doesn't work for you, you may find it easier to delay your breakfast by a few hours, until you hit the 12-hour mark since your last dose of calories the night before.

My half-and-half

In the USA half-and-half is 50% milk and 50% cream, which many people routinely put in their tea or coffee. No wonder the rates of obesity on that side of the pond are through the roof! Since learning about time-restricted feeding, I've started drinking my tea or coffee black, with no sugar, until I hit the 12-hour mark since my last snack or sip of sugary drink the previous evening.

I've also been using a brain hack for many years that has helped me to reduce my calorie intake effortlessly. As I'm not a great fan of the taste of soya milk or almond milk, by adding it 50/50 with semi-skimmed cow's milk I'm happy to stick it on my daily bowl of unprocessed porridge oats (topped with a guest fruit to get one of my five-a-day in the bag straight away). That reduces my intake of fat from milk by 50% every single day. And I've found that now I don't mind so much using just the soya milk whenever I run out of cow's milk.

Using a combination of a 12-hour fast and my healthy version of half-and-half I lost 5 kilograms. And I wasn't even trying to lose weight. That's how well it works!

– Jack

Everyone is different, so see what works for you. If you do decide to give it a go, don't forget that all milks contain some kind of sugar (e.g. lactose) so it's important to drink your tea or coffee black until it is time to break your fast! Beers and wines also contain lots of calories so just one sip late in the evening resets the timer to zero when it comes to taking note of

when you've started your daily fast. Thinking not just about what and how much you eat but also *when* you eat is as important for your brain health as it is for your body.

Chapter takeaways

- Try to stop eating a meal before you feel full to give the leptin time to reach your brain and flick off the hunger switch – *hara hachi bu!*
- Fibre doesn't just keep you regular. Certain gut bacteria chow down on it, making chemicals that make you feel full sooner as a waste product, to help you stop eating before you overdo it!
- Gut bacteria really do have an influence on your mood. The good bacteria need all the support they can get, so eat foods that nourish them so they can thrive, to keep yourself feeling buoyant.
- Don't go making meringue out of your brain wires; too much sugar only leads to vandalism. *Do* have it as a treat, just *not* a *daily* habit!
- Make sure you're giving your brain the right fuel. Fill up with slow-release carbs each morning and when "topping up" between meals.
- Burn some fat by giving your gut a break from all food and sugary drinks for 12 or more hours per day.

Born To Move
"Sitting Is the New Smoking"

This headline appeared in the *British Journal of General Practice* in 2016 – the kind of magazine your local GP subscribes to so that they can stay bang up-to-date on the latest hot topics in the important business of keeping us alive and well. The article was commenting on the shocking revelation that spending too much time sitting down now kills even more people than smoking. It pointed out that, as animals who spent most of the past 6 million years up on our feet all day long, we're simply not designed to spend so many hours each day sitting on our behinds.

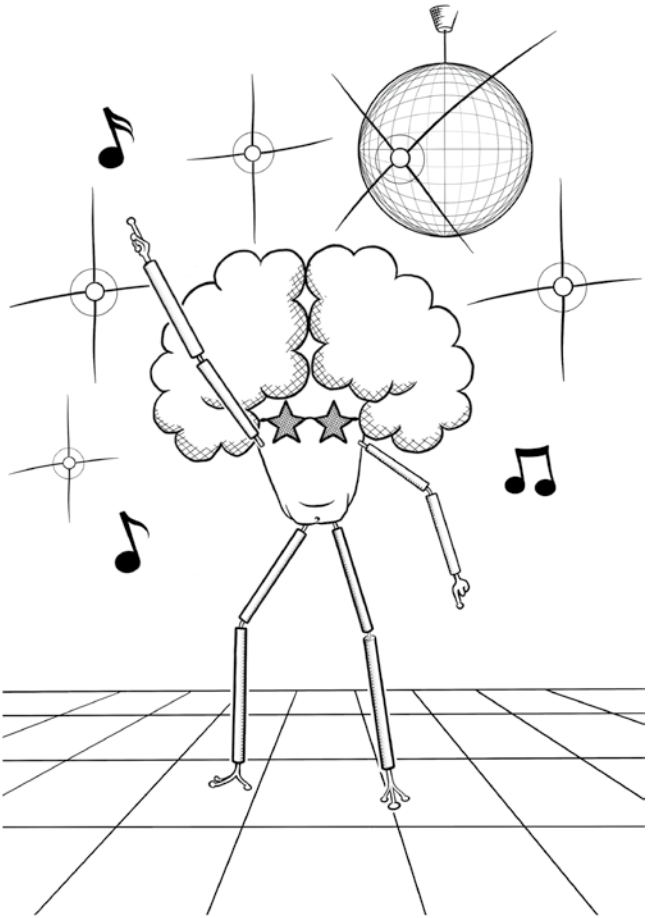
Forget body beautiful. That's genuinely the least important aspect of exercising on a regular basis. Aiming for body beautiful is also unhelpful. The fat can take forever to shift, requiring long, hard sessions of exercise that usually result in perpetually aching muscles – hardly an incentive to repeat the experience any time soon! On the other hand, if the carrots you dangle in front of yourself to encourage the habit of regular exercise are the various brain benefits, it's not only much easier to achieve, but also considerably less effort. Hooray!

Rock the basal ganglia

The basal ganglia are a cluster of interlocking brain networks right at the centre of the brain that trigger the urge to move. Brain scanning studies have shown that the activity here actually pulses with the rhythm of the music – explaining the urge to tap your foot or nod your head to the beat.

(Continued)

This natural tendency to match movements to the beat means that listening to high-tempo music allows you to exercise past the point at which you'd normally have thrown in the towel. It can increase your speed, strength and stamina, whether you're running, cycling, swimming, doing circuit training or high-intensity interval training. And, despite all the extra effort you're putting in, any feelings of bodily discomfort are significantly *reduced* compared to exercising without music.



The media tend to focus our attention on fad diets and exercise regimes that quickly bash out-of-shape bodies into beach-ready shape with "miraculous results." But as far as your brain is concerned, losing some of that unsightly subcutaneous fat or getting your muscles all big and bulging are relatively superficial side effects compared to the profound improvements to your mood and cognitive abilities.

Do it for your brain's sake

The good news is that, unlike the frustratingly long periods of dedicated training it takes to yield the slightest visible enhancements to the appearance of your body, there are several immediately noticeable improvements for your brain. All you need is to do some moderately intensive exercise every day or two.

One key thing your brain gets out of exercise is more freshly oxygenated blood. Faster blood flow also provides an added benefit of quicker removal of the waste materials of metabolism that are constantly churned out by your busy brain. The brain gets these advantages because your heart ends up pumping faster and harder. This occurs in response to a familiar-sounding chemical that is released from the glands that sit on top of your kidneys – adrenaline – and also because of a set of brain wires that branch off your spinal cord to innervate more or less every organ in your body – your sympathetic nervous system.

Up to 1 litre of blood passes through your brain every minute.

These automatic hormonal and nervous system responses to exercising your body increase the speed and depth with which the lungs inflate and deflate, upping the intake of oxygen and removal of carbon dioxide waste. The adrenaline also causes glucose to be released from glycogen storage. So not only does exercise mean your brain is getting more blood

passing through it – blood richer in oxygen and with carbon dioxide waste disposal well in hand – it also increases availability and consumption of glucose, which means more energy, heightened awareness and better focus.

Improving the supply of glucose-packed, oxygenated blood gushing through it is important because, like all brains, yours has no room for energy storage. Virtually every cubic millimetre of the space inside your brain is taken up by 86 billion wire-like brain cells and a further 86 billion glial cells that provide the support network on which the whole brain communication infrastructure is built and critically dependent upon. There's simply no room for storage!

The one-minute-skip

Do you ever sit down to start work and find you just can't get focused? You're surfing the internet, trying to clear your inbox, browsing social media – anything to avoid getting down to the nitty-gritty? While many people have unexpectedly found themselves working from home in recent years, I've been doing it for over a decade, so I've had plenty of time to work out a few brain hacks to increase my productivity and jolt myself out of these inevitable periods of procrastination.

If I can't concentrate but really need to, one of the most valuable brain hacks I've discovered (and often use several times a day) is to grab my skipping rope and do a "60-second skip." It's just enough to trick my body into releasing adrenaline into my bloodstream and activate my sympathetic nervous system, but not enough to get all hot and sweaty. When I sit back down again with all that freshly oxygenated, hormone-packed blood surging through my brain, I find I can finally get down to work straight away, with enthusiasm!

– Jack

Every single one of those neuronal and glial cells rubs up alongside a tiny blood vessel called a capillary – a lifeline to those essential energy molecules that need to be readily accessible if you are to stay alive and thrive. With nowhere to store the glucose and oxygen that combine to release the energy to keep those brain cogs turning, each cell is 100% reliant on a constant flow of blood via these microscopically thin tubes that weave an intricate web throughout the massive ball of brain gloop sloshing around inside your skull. These tubes can easily get clogged if you don't do what the human body is designed to do – namely, move!

Consistent high performance

Exercise is a tool that can be used to change your mood in an instant. Several other powerful hormones are automatically released into your bloodstream when you do even a short burst of exercise, exerting a positive effect on your mood. A 10-minute jog round the block followed by a quick shower is all that's required to make you feel much more alert and upbeat. Considering that 10 minutes is just 1% of your waking day, surely you can spare that?

The time invested in a short bout of exercise will be more than compensated for when your brain is positively zinging with everything it needs to function at the best of its abilities. And one clever trick that has proven time and time again to lead to huge improvements in fitness is to set the bar low, on the understanding that the only way is up. That means that if you do an 11-minute jog one day instead of your usual 10 minutes, then you should try to stick to the 11-minute jog regime from then on. As you get fitter, you'll naturally find yourself inclined to go for a bit longer, so that little by little, without any nasty aches and pains, your heart and skeletal muscles will go from strength to strength.

Try not to think of body builders pumping iron on the beach or Olympians performing superhuman feats of athletic prowess. Daily, gentle exercise is all you brain really needs to consistently boost its performance.

Your DNA is stored in 23 pairs of chromosomes that live inside the nucleus of every single cell in your body. At each end of these chromosomes is a protective cap called a telomere that protects the DNA, a bit like the plastic caps at ends of your shoelaces. These telomeres are also vital to the process of duplicating the DNA so that your cells can multiply when replacing damaged tissues.

As we age, these telomeres tend to get shorter and shorter, which means our bodies generally get worse and worse at replacing damaged cells. Eventually we end up with such short telomeres that they can't replicate at all. And that, as you might imagine, is bad news.

Happily we can all do something about this. It turns out that regular exercise triggers the production of telomerase – an enzyme responsible for making telomeres longer. Exercise is the key to longer telomeres! So people who exercise regularly are able to replace damaged cells in the skin, muscle *and* brain much more effectively than couch potatoes. This is why fitter folk look healthier on the outside *and* they can replace their hippocampal neurons more quickly, to sharpen up their memory and many other cognitive capacities.

The best part is that, once you've gotten into the habit of doing regular exercise for just a few weeks, your general mood will improve. That's because the blood vessels in your brain will become clearer than those belonging to someone whose only exercise is running for the bus once in a while. Your heart will be stronger, enabling it to pump blood more efficiently through not just your brain but all your organs. It's even good for your bones.

Unsung benefits

The cells in your bones are replaced more quickly if you take regular exercise than if you don't. The reason is that each time you put one

foot in front of the other, the forces produced when each footfall makes contact with the ground judders through your skeleton and causes two different types of cells to spring into action. Osteoclasts are special bone cells that nibble away any weak or damaged bone cells and then osteoblasts move in to fill the gap, multiplying and then hardening to keep your bones strong.

Taking regular exercise actually places extra stresses on *all* the cells in your body and brain, but they then respond by sending in cellular maintenance teams to fix everything up once you stop and rest. If you don't take regular exercise, these cellular maintenance teams get lazy and so *all* cells gradually fall into disrepair. Body and brain constantly adapt to what you spend your time doing, but only fully invest resources into repair work if you often move around at a brisk pace.

Regular exercise can be as effective (and in some cases more effective) as drug therapy for stroke and diabetes management.

Exercise is probably best regarded as a multipurpose tool that has both an immediate and a longer-term impact when it comes to increasing the efficiency of all your brain and body functions. It can give you a fresh perspective on problems that need solving by giving you the chance to mull things over away from the coalface of work and, at the very instant your heart starts pumping faster, it can snap you out of a gloomy mood.

Many people who've gotten out of the habit of taking regular exercise, or never developed that habit in the first place, find themselves coping with the negative impact of a sedentary lifestyle on their mood by self-medicating with sweet and fatty foods, or recreational drugs. The trouble with this approach is that the Reward Line adapts to regular doses of sugar, fat, alcohol and other mood-enhancing substances by pushing the bar higher and higher, meaning that you need more and more of

the substance you have a weakness for to get the good feelings you crave. Eventually, we feel compelled to continue taking those substance even if they no longer make us feel noticeably happier. From that point onwards, we're no longer acting on impulse when we give into temptation; instead, we are acting on compulsion.

A similar thing happens with exercise. Once you get into an exercise habit, you find yourself wanting more of those good feelings more often. The key difference is that a healthy addiction to exercise keeps your heart strong, your blood pipes clear and your brain drenched in natural, brain-manufactured, mood-enhancing drugs. Unhealthy addiction to exercise is, of course, also possible. Some people push themselves too hard, not taking rest days, exercising despite injuries and all the rest. Either way, the urge to exercise more and more comes down to endorphins.

Your natural opiates and cannabinoids

The most powerful positive mood change happens in response to *intensive* bouts of body movement because this triggers the release of endorphins. The reason we evolved to release these natural feel-good chemicals in response to *intense* exercise is mainly due to their ability to shut off pain in emergency situations. If you ever needed to run away from danger, fight off an enemy or take on any other potentially life-threatening challenge, you wouldn't want a twisted ankle or a stubbed toe to impede you.

Endorphins are also the reason people can sometimes walk away from a nasty car accident feeling totally fine, only to drop dead of their injuries a few hours later, such is their incredible power to eliminate pain and elevate mood. Our brains use them as a natural form of opium to numb inconvenient pain messages under conditions where keeping moving is potentially more important to survival than protecting the damaged body part from further damage.

Inside your brain there are no pain receptors, so brain surgeons can prod around in there without hurting the owner, even during procedures where the patient needs to be wide awake. Professional musicians are often kept awake so they can play their instrument while the surgeon operates, just to make sure that no brain connections vital to their ability to earn a living are accidentally snipped away!

You may think that brains, being brains, are fairly streetwise, but the truth is that they honestly can't tell the differences between you genuinely being scared witless and running for your life or just running on a treadmill in the safety and comfort of a gym. So the next time you want to feel high as a kite, a good, hard workout should do the trick.

The endorphin release that accompanies intense prolonged exercise is "designed by nature" to make you feel high so that you won't feel the pain that might otherwise convince you to stop. The bonus is that these endorphins will still be swimming around in your body when you get back from a lunchtime workout and continue with your work. Available to anyone, completely free, ridiculously powerful and perfectly legal, endorphins after a fairly long and intense run, cycle or swim are guaranteed to change your mood in a positive manner.

Research into the "runner's high" investigated how hard and how long we need to exercise before the endorphins come out to play. It turns out that to get that "high as a kite" feeling from *endorphins* after exercise, it takes nearly an hour (!) of pretty intense exercise to coax these powerful hormones out. While that might sound like way too much hard work to some, the great news is that the little cousins of the endorphins – the endocannabinoids – also have the power to boost mood and are much more forthcoming. They are released after just 10–15 minutes of moderate exercise. The high you get might be more subtle, but you only need to get a little bit out of breath to get there – ending up with a light glow rather than a torrent of sweat streaming down your brow.

Whether you're the type of person who loves to hit the exercise hard – getting drenched in sweat and totally out of breath – or instead prefers to take a gentler approach, the important thing to remember is that physical movement isn't just nice to have; it's essential to our psychological well-being.

Enter the iceman

Wim Hoff is an inspirational and energetic chap who lives in the Netherlands and spends much of his time performing seemingly superhuman feats like swimming under Arctic ice sheets for minutes at a time and hiking up Mount Kilimanjaro wearing just a pair of shorts. At first, many people weren't sure what to make of him, but he ended up teaching science a thing or two about some of the tremendous and previously unknown powers of deep breathing – a breathing style similar to that which comes naturally after exercising really hard.

His life took a tragic twist in 1995, when his wife committed suicide, leaving him to raise their four children single-handedly. He spent many

months feeling utterly distraught, unable to focus on anything but his crushing loss. In his desperation he began researching various cultural traditions in search of techniques he might use to get a break from the overwhelming stress and anxiety he'd been living with. Before long he found himself drawn to immersing himself in ice cold water, which – because he was living on a houseboat in Amsterdam at the time – was something he could do on a daily basis during the chilly winter months.

He also started experimenting with some unusual, rapid, explosive breathing practices he had stumbled across in his studies of Tibetan Buddhism. He soon realised that he could numb himself to the pain of the freezing cold water using the breathing techniques and then, once immersed, finally get some peace of mind from the endless rumination over his heartbreaking bereavement.

Pain receptors in the skin, aka nociceptors, are formed by three protein segments that can only send pain messages to the brain if they fit together snugly. This happens when the blood has its usual ever-so-slightly alkaline pH level of 7.35–7.45, but if the pH increases a little bit – making the blood even *more* alkaline – the three nociceptor subunits can't fit together properly. When this happens they are unable to send pain messages to the brain. Under these conditions the skin can feel the cold, but it doesn't feel unpleasant, because the nociceptors are inactivated!

By rapidly breathing in and out using his full lung capacity, a technique that expels more carbon dioxide from the bloodstream than usual, he was literally able to deactivate his pain receptors.

While rigged up to laboratory equipment, Wim "The Iceman" Hoff proved to the world that his breathing technique increases the pH of his blood (up to around 7.75 from the usual level of about 7.4). When carbon dioxide is eliminated from our cells, as a waste product of the metabolic

processes that release energy from glucose, it dissolves in the blood to form carbonic acid. By using repeated cycles of deep hyperventilation followed by breath-holding, he was able to blow away more carbon dioxide than usual. This meant he could reduce the amount of carbonic acid in his bloodstream, making his blood more alkaline, which deactivated his skin's pain receptors.

The next time you jump into cold water, focus on how it changes your breathing. You'll notice that you *automatically* start breathing in a way that leads to exactly this outcome: rapid panting where the out-breath is longer than the in-breath. Wim's process of deactivating pain receptors – via a breathing style that tends to reduce the acidity of the blood – seems to be hard-wired into our reflexes!

In season one of a TV series I presented called Secrets of the Brain, *I had the pleasure of flying out to Amsterdam one New Year's Day to meet up with the Iceman himself. The following day I found myself neck deep in a freezing cold lake in the middle of the Dutch countryside with Wim and about 200 other Dutch people, after just one hour's training!*

Having met this inspirational man in person, I noticed that there were two important things about him that often go unmentioned. Number 1: his enthusiasm about the fact that there is nothing special about him and that anybody could do what he does. Number 2: he cannot keep still.

Every five to ten minutes he runs off to do some pull-ups, push-ups, the plank, a handstand – whatever spontaneously takes his fancy – whether he's in the comfort of his home or at a conference just minutes before he's due to go on stage. Which begs the question: could this propensity to be in perpetual motion be an important part of his incredible metabolism?

– Jack

Molecules of movement

Myokines are special molecules released from muscles when they've been used to do exercise. These agents are sent out into the bloodstream to communicate with various organs, all over the body, flicking various genetic switches on and off, to put all your systems into "exploration" mode.

When these myokines reach the brain, genes responsible for manufacturing a really important substance called Brain-Derived Neurotrophic Factor (BDNF) are switched on. BDNF is released throughout the brain, but in the hippocampus (DG and EC stops), it triggers the birth of brand-new brain cells in your memory banks. It also promotes the birth of new mitochondria – the actual powerhouses inside each brain cell that release energy from glucose. So pumping the muscles with regular exercise means that not only do you get new brain cells, but older ones become more energised, which enables them to build new connections faster.

The next time you're struggling with your motivation levels and feel like you simply can't be bothered to do a short jog around the local park, ask yourself this – do you really want to end up with dementia? It may sound a bit extreme, but people who manage to do 20 minutes of moderate exercise on a daily basis have more BDNF in their brains than those who don't. And because high levels of BDNF are known to protect the brain against dementia, getting your brain to release more BDNF is surely a great idea. If the mood-boosting, heart-strengthening benefits of regular exercise don't get you moving, might the fear of letting your brain slowly but surely fall into disrepair convince you?

If running really isn't your bag, fear not. Recent research has revealed that weight training does the trick too. In fact, anything that gets your muscles contracting on a regular basis should work just fine. So if it's raining outside, perhaps a bit blustery and cold, leaving you feeling distinctly reluctant to get out into the great outdoors, I'm afraid you have no excuses. Stick on your favourite aerobics tape, DVD, video file, YouTuber, Instagrammer or TikTok "influencer" and get your body moving.

Exploration mode

All this begs the question: *why* in the world would the activity of your skeletal muscles have such a powerful influence on your brain matter? The explanation is this: if your muscles are doing a lot of work, then it's probably safe to assume that you are probably moving from one environment to another. If you're doing a lot of moving around, then you're likely to be encountering new places, different people and having experiences worth remembering.

The memory banks of a brain that is visiting many different locations will usually have more work to do, in terms of creating memories, than a brain that isn't moving around so much. It will need more resources to keep track of where, when and with whom various experiences occurred, for future reference. That way the owner of the brain will be better positioned to recall where to go to repeat any positive experiences and also to stay away from the places, times and people where, when and with whom things didn't go so well.

The hippocampus tends to organise memories of your important life experiences according to *where* you were when they took place, so it makes sense that if you've visited more places, then you're likely to need to make more new memories than if you were less active. Put it all together and we have a likely explanation for why human evolution resulted in myokines being released from muscles to trigger BDNF release, which, in turn, leads to the birth of new brain cells and available energy resources, in your hippocampus.

As with most basic brain features, this process evolved long before the invention of the treadmill, the exercise bike and the cross trainer. So whether you're covering many miles when you exercise or zero miles because you're using gym equipment and staying in once place, either way your brain will respond to the myokines produced by contracting muscles to trick your brain into upping its BDNF production. Throughout adulthood your brain gives birth to new hippocampal neurons, just so long as you keep pumping those arm and leg muscles to trick your

brain into thinking you're covering a lot of ground, even if you don't actually go anywhere.

Better out than in

As mentioned in the "Flying Start" chapter, people who get outside into nature for two hours per week or more enjoy greater levels of happiness than those who rarely get out into the fresh air. It doesn't matter whether you do two hours all in one go or divide it up into six different 20-minute sessions to hit that target. Either way, people who get outside – into the park, countryside or coast – for two hours or more per week simply end up happier than those who don't.

Better still, the happiness-boosting impact of getting up close and personal with Mother Nature is *dose-dependent*, meaning the longer you spend doing recreational activities in natural spaces each week, the happier you become, up to a maximum dose of five hours per week. Any more than that doesn't seem to lead to any extra measurable benefit, but it doesn't hurt either!

Another benefit of exercising outdoors comes from running off the beaten track. If you choose to exercise cross country, away from paths, then you have to be extremely vigilant to avoid rolling an ankle or stepping in something unpleasant. This can provide a challenging workout for your brain as well as your heart and muscles. Keeping a close eye on where each foot lands to avoid potholes, obstacles and uneven surfaces requires incredibly fast thinking. This gets more and more challenging the faster you try to move, putting the balance and coordination stops in the Cerebellum Light Railway through their paces.

Assuming that you're now utterly convinced by the evidence that doing more exercise will improve your mood via endocannabinoid and endorphin release, give you better cardiovascular health to improve blood supply to your brain and increase the birth of new neurons in your hippocampus to improve your memory and cognition, hopefully you'll now

also be convinced to take your exercise outside rather than inside whenever possible as well.

Return of the iceman

Why did Wim Hoff first decide to slip into the icy waters of Amsterdam's canals? For peace of mind. He'd tried and tried to meditate, convinced by the evidence he'd heard about it being a promising way to get his mind off his troubles. But like many people, whenever he attempted to do it he would always get distracted and his mind would start wandering all over the place. Yet by swimming in icy water, he managed to find the inner peace he craved. Why is that?

Practitioners of mindfulness meditation often talk about the importance of being in the present moment. While this is true, there's nothing special about being "present" other than, by definition, it involves the *absence* of worries associated with events of the past or in the future. When your mind is fully immersed in the moment, it is *impossible* for it to be dwelling on the past or concerned about the future, both of which were driving Wim to distraction.

Regarding the past, he was understandably consumed with heart-rending questions about why his wife committed suicide. And as for the future, no doubt he would have been troubled by fears regarding how he was going to cope: earning a living while single-handedly raising four children. What he discovered through his self-experimentation was that, by immersing himself in freezing cold water, he could finally get himself squarely in the present moment – there was simply no brain capacity left for thinking about anything else, past or future.

This is the essence of mindfulness. And it doesn't have to involve sitting quietly focusing on your breath, although that works too, for some. Everyone is different in terms of techniques that are and are not effective in anchoring them, personally, in the present moment. Wim's experience may be particularly inspiring to anybody who has tried and failed to

meditate. All that matters is to spend some unbroken time in the present moment, irrespective of whether it is through exercise or sitting cross-legged under a tree that ultimately gets you there.

Tai chi and qigong are two Far Eastern traditions that enable people to get themselves in a daily meditative state using a physically active rather than passive approach. You may have seen TV footage of people on the streets of China all simultaneously performing complex movements of the arms and legs, which looks a bit like kung fu but in slow motion. The reason these practices are so effective at keeping the mind in the present moment is that you have to concentrate so hard on each part of your body to get your balance right and perform each move properly, that there's simply no room for thoughts about the past or future!

When you think about events from your own recent or distant past, or contemplate what may or may not happen in the future, you may have noticed that such thoughts often increase your anxiety levels. When it comes to the past we tend to focus on things that went wrong: our mistakes, our humiliations, our regrets. This tendency is inevitable because: 1) to err is human, so screwing up on a regular basis is inevitable, and

2) the only way to learn from your mistakes is to mull over what you could have done differently.

We humans have incredible imaginations with which we run simulations of possible outcomes that might have happened if we'd done things differently. That way, if we find ourselves in a similar situation again in the future, we can choose a better path. But our tendency to ruminate on our failures – that is, to brood about them too often, too deeply and to the detriment of our mood and health – can cause big problems in many people's lives.

The future is uncertain, by definition, and so thinking about it can also be stressful. We can never be completely sure what the future holds and despite efforts to *expect the worse but hope for the best*, many of us focus too much on the worst-case scenarios. If thinking about events of the past and possible happenings in the future are the source of so much woe, where can we look to find peace of mind? Once again: the present moment.

We'll come back to this topic later and, in particular, cover the brain changes that occur in people who *do* practice mindfulness on a regular basis. For the time being, just bear in mind that regularly practising being *in the moment*, as opposed to having your head forever fretting over the past or the future, is scientifically proven to be one of the best strategies for managing stress.

While being *in the moment* is traditionally associated with stillness, it can also be achieved by concentrating intently on your own body movements, such as when practising martial arts like tai chi (or swimming or skipping, for that matter). Finding peace of mind with movement will get your muscles contracting and those myokines travelling up to your brain to stimulate some extra BDNF, keeping those memory banks in good shape – so why not kill two birds with one stone?

Chapter takeaways

- Your brain, as well as your body, benefits enormously from *regular* exercise – and you don't even need to exercise too hard.

- If you want to feel great, do endocannabinoids. If you want to feel truly amazing, keep going and do endorphins instead!

- You don't have to join a gym to do regular exercise. You can exercise anywhere. And if that anywhere happens to be outside – well, that's even better for your brain.

- Humans are born to move. The more you move, the more your muscles release myokines, which travel up to the brain, triggering the birth of new neurons in your hippocampal memory banks.

- Mindfulness through movement is great for your health, well-being and cognitive performance. Whether you immerse yourself in icy water, do tai chi or listen to music while exercising, being completely in the present moment sorts your brain out brilliantly.

All Aboard the Stress Express!

Stress is *not* the enemy

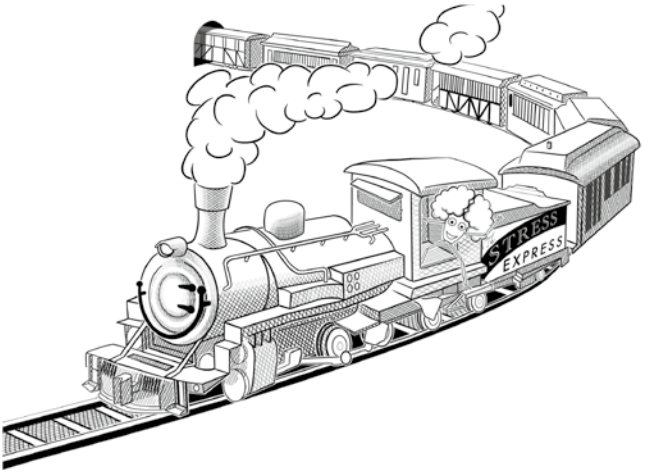
Stress is a friend. Without it you'd be constantly flummoxed. You'd never get anything done and you'd certainly never manage to rise to the challenges presented by an ever-changing world. Stress, or more precisely the main stress hormone cortisol, is key to your ability to respond effectively to change. Without the ability to release such hormones, you'd lack the behavioural flexibility that enabled you to do every worthwhile thing you've ever done.

As long as it's properly managed and appropriately harnessed, stress can provide many benefits, but only if you don't let it overstay its welcome. Cortisol works best in short doses. Too much over long periods of time, on the other hand, can be extremely detrimental to your health. If you want to keep cortisol as a friend rather than a foe, it's best that you don't let it hang around too long.

In recent years, stress has got itself a bad name what with all the stories of stress-related burnout that are all too common in the press and in many workplaces. The sad stories that give stress its bad rep only happen so frequently because stress is such a broadly misunderstood subject. When faced with stressful situations at work, most people respond not only by working harder, but also by working much longer hours. While this response is totally understandable, it's also completely unhelpful, because it gradually renders the person less and less able to work effectively. Tired and irritable, they gradually become more and

more stressed! They start taking stress home with them, they take it to bed with them and they even take it on holiday. Lack of quality time spent with family and friends means that they get even more stressed. With tensions mounting and tempers flaring, guess what? More time is spent at work to avoid conflict at home!

What has happened is that they've unsuspectingly boarded an ever-accelerating, nonstop train with no control over its speed or where it's heading. Feeling like they're unable to slow down or hop off, they just keep going, riding along on the runaway *Stress Express* – just to overcome a few problems at work.



They have no idea about how stress is created in their body, nor a clue as to why their brain is making them feel so stressed out. As passengers with no access to the controls, they'll inevitably end up coming off the rails.

Stress heads

Stress hormones are indeed a double-edged sword. A moderate amount can truly help to improve performance by mobilizing glucose for immediate use in body and brain, while simultaneously switching your

attention systems to action stations. Large amounts, on the other hand, can dramatically impair performance, even in the short term, by pushing all systems into overdrive.

Battle of the sexes

High stress levels have a different impact on male and female brains. Under intense duress, men generally tend to find risky decisions more appealing, but women tend to lose their appetite for high-risk choices. While this may be a recipe for conflict in many households, there could be method in the madness. If, under stress, male-female partnerships view risky decisions from opposite perspectives, both sides of the equation will have been considered before the final decision is reached. It may actually improve choices overall, as long as both parties listen to each other!

The importance of learning to control your cortisol levels cannot be emphasized enough here. Chronic stress – high cortisol levels over long periods of time – changes your body in a very unwelcome fashion. It can hobble your immune system, make you fat and cause both muscle wasting and high blood pressure.

These, however, are all fairly minor in comparison to what it can do to your brain. Chronic stress interferes with the connectivity on the Hold Line, which runs between Frontal and Parietal brain districts on the outer surface of the brain, reducing your working memory capacity and, as a knock-on effect, your problem-solving abilities too. Worse still, it *increases* the synapse-covered dendritic branches in your amygdala stop – leaving it hypersensitive to perceived dangers. It also *reduces* the synaptic density in your hippocampus, causing your memory banks to shrink a little.

The net results of all this are increased fear and anxiety levels, to the point where dangers and threats seem to be lurking around every corner (whether they're really present or just imagined), combined with

impairments in memory recall that render all aspects of cognition less effective. The secret to avoiding such a disastrous state of affairs is to take stress management really seriously. Consider it an important part of your job. When it comes to achieving this goal, understanding where stress actually comes from is a great first step.

Cortisol the motivator

The rather unpleasant feeling of being stressed is actively created by your brain in response to the presence of stress hormones. The relay race of chemical messages that results in the release of these stress hormones occurs when the brain detects a problem that needs urgent attention.

Your hypothalamus stop sits on the underside of your brain and has a structure called the pituitary gland hanging off the bottom of it (see Appendix, Inward-Facing Brain Tube Map). When a stressful situation arises, your hypothalamus sends a hormonal message the short distance to your pituitary gland, causing another hormone to set sail in the bloodstream all the way down to your adrenal glands, one sitting atop each kidney. These stimulate the outer layer of the adrenal glands to manufacture cortisol and other stress hormones that actually orchestrate the body and brain's stress responses.

Cortisol has VIP access to every single cell in the body. Unlike most of the other chemical messengers used in the human body, cortisol is lipophilic, or "fat-loving." That means it can mix freely with fatty substances and so passes unchallenged through cell membranes (which are themselves built from a pair of ultra-fine layers of a fatty substance known as a phospholipid bilayer). Most chemical messengers are hydrophilic, or "water-loving," which means that when they come into contact with the cell membrane they cannot pass through it. The fatty bubble of membrane surrounding the contents of each cell is how they keep the components that belong inside in and those that don't out. Cortisol,

however, slips through these membranes like ghosts through the walls of a haunted house.

Not only can cortisol enter into every single cell of your body and brain, but it can also get inside the very nucleus of each of these cells, where all your DNA resides.

The 23 pairs of coiled double spirals – one set from your mum and one set from your dad – is where the genetic code for every single protein required to build a human being resides. Special receptor molecules on the DNA bind to any cortisol that happens to have found its way inside the nucleus, causing certain genes to be switched on and others to be switched off, like a sound engineer pushing sliders and twiddling knobs on a mixing desk when recording a song.

The impact of these hormones is so profound because they effectively switch every cell in your entire body into a different mode. By orchestrating which genes are switched on and off, cortisol puts your body and brain into a mode that's best suited to deal with (and ideally remove) the source of the stress you're experiencing. This is the point that people often miss when they get stressed about being stressed. They don't realize that a little bit of stress actually helps them get things done and get to the bottom of whatever problem is causing them to release the stress hormones in the first place.

Even the mildly unpleasant emotional state of being "a bit stressed" is helpful. It motivates us to act – to take steps to try and address the situation that is creating the problem. We humans are highly efficient creatures, masters at conserving energy unless using it up is really necessary. To put it another way, we're lazy!

Discomfort is an extremely effective way of motivating us to act. If we didn't feel stressed, cortisol wouldn't be able to work its full magic and nothing would ever get done.

Cortisol induces a variety of physiological effects that together provide us with more energy. In so doing it plays a key role in enabling us to adapt to change. Cortisol enables us to mobilize resources in response to internal changes, such as an increased demand for energy from your brain cells when a work deadline is due to be met. It also enables us to respond quickly to external changes, like getting an unexpected call informing you that a loved one has been taken into hospital or that, at very short notice, you've won a weekend away!

At times we all worry and end up getting stressed out about things that we shouldn't. They are either things that turn out to be figments of our imagination or that are real but beyond our control. The reason for unnecessary stressing is because of our brains' inability to distinguish between what is real and what is vividly imagined – no matter how ludicrous, in the light of day, those imagined events might seem!

Your brain makes little distinction between what is real and controllable and what it believes is causing the perceived problem, which can all too often be based on flawed assumptions.

As soon as you start to give something a lot of serious thought – whether it is real, imagined, within your control or not – your cortisol stress system will swing into action. That's why, when you suddenly wake up in the middle of a horrific nightmare, your heart is pounding, your breathing is fast and shallow and you're utterly drenched in sweat.

Give this a go: close your eyes and imagine that having just cut a fresh lemon in half, you're now holding one half of it in your hand. Bring this juicy half up to your nose and take a really big sniff. Notice how strong its citrus smell is. Now squeeze as much juice as possible out of it into a tablespoon and hold the tablespoon near your mouth in readiness to drink the contents. Now very slowly, without spilling any, bring the spoon closer and closer to your

mouth. Get ready to drink, open your mouth and – stop! Chances are that your brain has ordered extra saliva be produced in your mouth in an attempt to dilute the citric acid – a real physiological response based on an entirely imagined sensory scenario.

Postponing battle

As well as increasing the amount of available energy for body and brain to meet ever-changing demands, cortisol also has an enormous impact on your body's defence systems. Under normal circumstances, when an invading lurgy is detected, your ever-alert immune system will immediately spring into action. The trouble is, in using all the weapons at its disposal to fight off the bug, it will more than likely cause some discomfort, possibly pain, and at the same time make you feel unwell as your energy is sapped in the struggle to repel the uninvited invader. For example, in combating a throat infection, your immune system's attack on it will create swelling, making it painful to swallow and leaving you feeling under the weather.

In times of crisis, when you really do need to get on with something, cortisol will temporarily hold back your immune system from getting fully stuck in until whatever it is you need to get done has been done. It sends a powerful message to your disease defence system that effectively says, "Now is not the time for me to feel ill; I can't afford to spare the resources right now, so go away!" Fighting disease with our vast armies of immune cells is an extremely energy-consuming activity. By postponing your immune system's response, all available energy can be channelled into dealing with the pressing matters at hand.

It's hardly surprising then that performers, despite suffering from a multitude of ailments like anyone else, still manage to get up on stage, temporarily forget about all their aches and pains and deliver great performances. It's also not surprising that most self-employed people will tell you that the best way to avoid falling ill with the 'flu is to become self-employed!

Pathetic is good

The helplessness that we exhibit when we fall ill is actually a behavioural set piece, instigated by our immune system to prevent us from wasting energy moving around and fretting over the concerns of everyday life. Feeling and acting pathetic when ill helps us to conserve valuable energy so that it can be invested in the singular pursuit of evicting invading bugs and infections. Some people pride themselves on being able to keep working despite feeling wiped out, but they're totally missing the point. In the long run many people live to regret using this approach too often. If you try to postpone fighting all illnesses indefinitely, they may well develop into an even bigger threat to your health, perhaps even a mortal one.

Who's driving your train?

Travelling on the *Stress Express* is not a problem providing *you* are the one doing the driving. If you want to regard stress as a friend and fully utilise the many positives that it has to offer, you must be the one that decides when and where you slow down, when and where you stop and when and where you get off. In other words you and not the outside world must be the one in control, running your life.

Rest stops along the way are extremely important to give your body and brain a chance to do some deep cleaning and eliminate any bugs lingering in your system due to stress-induced postponement of a proper, thorough, full immune response, operating without the cortisol impediment. There are several different categories of rest that you should consider. Each of them is vital, not only in terms of reducing cortisol to more manageable levels, but also permitting important cellular maintenance work to take place to keep your body and brain working well on timescales of years and decades, as well as days and weeks.

Taking small bite-sized periods of time out throughout the day helps you to get through each week better. Ensuring that your weekends, or whatever days off you do get, allow time for some periods of total rest will help you through each month more effectively. As well as these, what really does help is if you take a stress-free holiday each year. It will allow your overworked brain to do some deep cleaning and seriously needed repair work. An uneventful or even boring holiday is perfect in this regard!

Reducing cortisol with laughter

Laughter eliminates stress by reducing levels of cortisol and boosting happiness. It's an invaluable tool when used appropriately during stressful interactions at work and at home. Making a carefully timed comment that causes people to laugh doesn't just reduce your own cortisol levels; it also brings down stress levels in those around you too – a welcome effect that everyone benefits from.

You might even consider trying a session of "laughter yoga," a bizarre group activity that involves laughing out loud in a variety of different ways. It is the most buttock-clenchingly cringey experience you'll ever have, until a few minutes in, when the utter ridiculousness of what you and everyone around you are doing will hit you like a ton of bricks. At that point you cannot help but get the giggles for real. Eventually you'll find yourself laughing so hard that it hurts. It is genuinely one of the most stress-relieving things I have ever done. The mantra of laughter yoga is "Fake it, 'til you make it."

– Jack

Periods of rest where you can fully unwind are essential if you want to ensure that your brain rises to major challenges in the months ahead. They will help to ensure they are dealt with to the best of your ability and without causing any long-term damage to your health. Your brain may be the most sophisticated piece of bio-wetware in the known universe,

but expecting it to work at its absolute maximum all of the time is just wishful thinking bordering on the utterly bonkers.

Like car engines, brains need regular maintenance and that requires rest. Expecting it to carry out its own running repair work while working flat out would be like expecting someone to retarmac a high street in rush hour without redirecting the traffic. Imagine it: a convoy of lorries, vans, cars, bikes and pedestrians all in a big hurry to get from A to B while an infrastructure engineering crew are scurrying around between the vehicles trying to do some much-needed road works. The best you could expect would be to fill in the odd pothole here and there. Well, that's just what it's like for your brain when you're expecting it to run at 100% of its maximum capacity, 100% of the time and, at the same time, stay in tip-top, full working order! If you want to get the best out of it, running repairs on the job will only keep it performing well for a limited period of time. Before long, it'll go beyond the point of no return and you'll slowly begin to conk out. If you really do want it to deliver on demand and put in peak performances over a period of decades, it needs time to catch up, to rest and repair properly.

Whenever you stop moving around, torn muscles can be rebuilt, cellular debris can be cleaned away, damaged DNA can be repaired and food in the stomach can be fully broken down. The nutrients and building blocks from food can be properly absorbed into the bloodstream and old bone cells can be gobbled up to make way for stronger, healthier, new ones. On top of all this, repairs can be carried out on your organs to make sure they are able to function fully, each performing its own vital role as efficiently as possible.

This kind of maintenance is very important for your body, but it's *extremely* important for your one and only brain. On a day-to-day basis it will of course do whatever it can in the natural lulls, repainting some of the old road marking and relaying the odd cracked paving slab here and there. But only with actively created restful gaps of recuperation time, between your rush hours of intense mental and physical activity, can the serious work get underway.

Gom time

Once or twice a day I take a couple of minutes out just to pause, step back, relax and focus on what lies ahead. I call it gom time. ("Gom" is the Tibetan word for meditation). All I do is sit somewhere quiet and take a few deep breaths in and out while picturing whatever it is that I next need to be getting on with. I use a very effective, quick and well-known technique called "7-11 breathing" whereby you simply breathe in while counting to seven and breathe out counting to eleven.

The key is to take full breaths, right into your belly, and breathe out for longer than you breathe in. I find it really helps to unclutter my busy mind and it certainly helps me to be more productive. I use it to "power up" so that I'm ready for the next big challenge or to "power down." For example, when I'm driving home, having spoken at a conference, I pull into a lay-by just down the road from where I live and allow myself some gom time.

I do this to try to bring my spinning head down from travelling at a thousand miles per hour so that, when I do step though my front door, it's going at a much slower pace and I'm able to enjoy precious time with my family. And, to help make sure there's no stress tagging along behind, I leave my luggage in the car, only returning to get it later on once I've completely unwound.

– Adrian

"Trying" to get to sleep?

"Trying" to "do" anything involves different areas of your brain working together to perform a task. You cannot *try* to go to sleep (well, you can *try* if you want, but it just won't work very well!) because trying suggests effort, which generally has the opposite effect on your brain than the one you're looking for.

"Allowing" your brain to "fall" asleep is a better way of thinking about it and the mindset that facilitates this process is all about surrender. Getting frustrated that you cannot get to sleep is the worst thing you can do, because frustration is an active process, not a passive one. Instead of slipping into neutral, you're revving up your brain.

One thing that can make getting off to sleep particularly elusive is getting caffeine intake wrong. While many people avoid caffeinated stimulants like coffee in the evening, most don't realise that they should be avoiding them *entirely* after midday if they have trouble sleeping. That's because, with a half-life of six hours, caffeine lingers in the bloodstream for a very long time. Half-life is the time it takes your body to rid itself of half of the caffeine. So, to reiterate a point made earlier (in the hope that the repetition will make it stick): if you have four cups of coffee in you at noon and drink no more caffeine at all for the rest of the day, you will still have one whole cup of coffee's worth of caffeine in you at midnight!

You'd be amazed how many people admit to being lifelong insomniacs but also happily drink coffee or tea all day long. Some people say they get off to sleep just fine after a cup of coffee, but do they *stay* asleep for the eight solid hours that they need to be at their best? No chance!

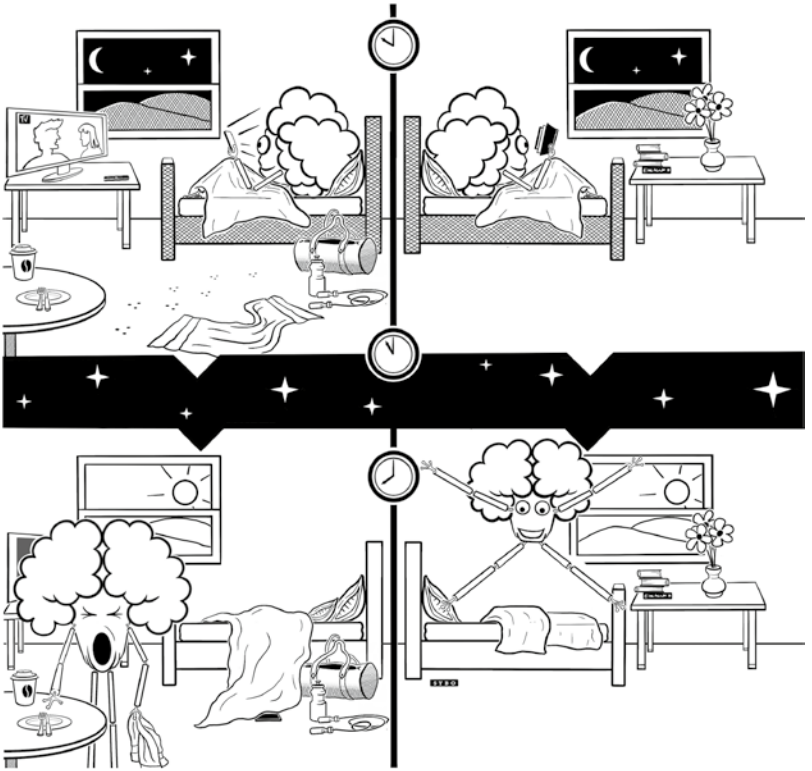
Beyond cutting out all caffeine after midday, there are many things that people who have difficulty getting off to sleep, or staying asleep for a full seven or eight hours each night, can do to help their brain sleep better. The first step is to start thinking of your bedroom as a sacred environment dedicated to sleep. That means making it completely free of any unnatural stimulation, especially electrical appliances like TVs, computers, tablets and smartphones. It doesn't matter whether you're using those devices for work, rest or play; they will be stimulating your brain at a time when it needs to be bored into sleepy submission, coaxing it into the land of nod with *a complete absence of stimulation*.

If you watch television in bed just before you go to sleep, you're inadvertently making your brain more active when you really want it to start switching off. If you use the internet just before you sleep, again you'll be getting it all excited when it should be winding down in preparation

for drifting into sleep. The only activities that should ever take place in your bedroom at night are sleep and sex.

> Your brain is your most important sex organ; it's what turns you on! Your largest sex organ is your skin – all 1.8 m^2 of it, the size of a single bed sheet. And sex, as it happens, is one of the best antidotes to stress.

Reading a novel at bedtime isn't too bad, particularly if it's the only chance you ever get to read, but only so long as what you're reading isn't too exhilarating! Also be careful what you read from. One study showed that people who do their bedtime reading on an eReader had 50% more cortisol swimming around in their bloodstream than those who read a traditional ink on paper book.



Whatever you do, don't read or watch the news just before bedtime. There's nothing worse than coming face-to-face with the world's endless litany of death, violence and outrage for leaving you tossing and turning through the night as your brain struggles to process it all.

The great thing about keeping the bedroom as a place where only sleep (and sex) happens is that, after just a few weeks of training, your brain will have come to strongly associate that particular room with peaceful slumber. Eventually, the moment you think about going to bed, even before you've crossed the threshold into your bedroom, it will already be going through the process of shutting itself down and getting into "sleep mode."

Sixty crucial minutes

Another thing you can do to help yourself get off to sleep swiftly is to make sure you don't do anything that might increase your body temperature in the crucial sixty minutes before bedtime. That means making sure that you've eaten your last meal of the day at least an hour before bedtime, so that you're not all bloated and releasing heat via the process of digesting a big meal while falling off to sleep. Make sure that any intensive aerobic exercise is taken as early in the evening as possible so that your muscles aren't still releasing extra heat and the stimulating adrenaline has had a chance to be fully cleared out of your system. If you shower or have a bath in the hour before bedtime, make sure it's lukewarm, or at least not *too* hot, or you'll be absorbing too much heat from the water.

The problem with doing intensive exercise, eating a huge meal or having a hot shower or bath too close to bedtime is that your brain needs to cool by 1°C before it can get off to sleep. To aid this process, the blood vessels in the hands and feet dilate to help radiate heat away, bringing your core temperature down, which in turn helps to cool your brain – hence the desire many of us feel to poke our feet out from under the bedcovers!

If you create extra heat in any way, whether it's given off by recently worked skeletal muscles, absorbed from hot water or released as your gut breaks down bonds between food molecules, it makes it harder for brains to get into sleep mode. If you're not a sound sleeper, it really does pay to make the last hour of your day as dull as possible!

If you want to get a good night's sleep, the last sixty minutes of the day must be as stress-free as possible. The bedroom should be a place dedicated to rest.

Nocturnal rewards

A few years ago I found myself constantly waking up in the middle of the night and was finding it almost impossible to get back to sleep. My lack of sleep began to have a huge detrimental effect on me. As I continued over a period of months to struggle with my recurring nocturnal problem, I was finding it increasingly hard to concentrate at work. I lacked energy, felt lethargic and became increasingly short tempered and ratty with people around me.

It became – and please excuse the pun here – an ongoing, living nightmare. I used to do a whole variety of things to try to make myself feel tired and hopefully get back to sleep. I'd sit up and read books, go and get a drink, watch TV, make myself something to eat, take a bath or, on some occasions, go out for a middle-of-the-night stroll. I'd do practically anything if I thought it was going to result in me being in the same enviable position that the rest of my family were in – fast asleep!

None of these things I tried ever worked. Then one day someone gave me an absolute gem of a tip. They explained that all the things I was doing to try to get back to sleep were the very reasons I was waking up in the first place. By doing all those leisurely, enjoyable things in the middle of the night, I was rewarding my brain for waking me. They

(Continued)

advised me that if I didn't want to continue waking up every night, the best thing to do the next time it happened would be to get up and do something that I hated doing, like cleaning the oven or washing a floor. I tried it. I got up and cleaned the oven. Apart from the odd occasion, I can honestly say I've not woken up in the middle of the night on a regular basis ever since.

– Adrian

Bedroom detective

For those who struggle with sleep, you might want to do a bit of detective work to improve your chances of sleeping better.

Firstly, do you try to go to sleep and wake up at the same time every day? Your brain is a creature of habit. If you go to sleep and wake up at roughly the same time *every* day, that makes your brain's job of regulating a zillion different processes *much* easier. The most unpopular part of putting this insight into practice is that it means sticking to this schedule during the week *and* at the weekend. That said, it's proven to be a brilliant way to improve sleep for those not getting enough of it. And that means anyone who often feels tired during the daytime.

Secondly, it's important to get outside in daylight whenever you can during the daytime, and to make sure you dim the lights in the evening hours. This gets your hypothalamus stop in the rhythm of pumping out the sleep-inducing hormone melatonin at night and *not* during the daytime. If you get too little light in the day, too much light in the evening – or worse still, both – these rhythms get out of whack and interfere not just with your sleep but also with appetite, digestion and glucose metabolism. Eek!

The other main causes of sleeping difficulties are usually light and sound pollution at night. These can often be remedied with blackout blinds,

a sleeping mask and ear plugs and/or a bed that doesn't creak. Just because you've got used to your bed squeaking every time you roll over at night doesn't mean it's *not* waking you up and reducing the quality of your sleep without you even realising it. The trouble is that, by the time you actually wake up, you often have no memory of what it was that woke you up! This may have been happening for years and you're still none the wiser. Don't take any chances – sort it out!

Finally, give serious consideration to buying a new, *modern* mattress. More often than not a lumpy mattress – perhaps with a few broken springs pushing up from beneath you – is to blame if you regularly wake up in the middle of the night, despite having addressed the other possible causes. Or do your scratchy, ill-fitting bed sheets have a tendency to bunch up in the night? Or perhaps those pillows heat up your head or give you a crook in the neck? Replace them!

Given how important sleep is for your physical and mental health, spending ever so slightly more than you can comfortably afford on a decent mattress and bedding should *not* be considered a luxury. Think of it as an important investment in your health and brain performance. After all, any improvement in sleep will improve your memory, reduce anxiety, make eating healthily the next day easier, remove toxins from your brain *and* improve your overall well-being across the board. A veritable bonanza of benefits!

Chapter takeaways

- Stress is a friend, not a foe, so long as it doesn't overstay its welcome.
- Be the driver, not a passenger, on the *Stress Express*. Stop when you need to stop.
- If you want to reduce cortisol and stress levels – make space for gom time.

- Rest, and in particular sleep, is vital if you want to give your brain a chance to catch up with much-needed repair work.

- Keep the last sixty minutes before going to bed as stress-free as possible. Don't "try" to get to sleep and if you do keep waking up in the middle of the night, go and do a household chore that you hate doing!

- Being stressed suppresses the immune system, which can be convenient in the short term by helping you to get more done, but if you never give in to feeling ill it could leave you vulnerable to serious long-term health problems.

- When you're next up for an award, remember to thank cortisol.

"Smart" Drugs

Everyone's on drugs!

Do you numb the pain of a headache with aspirin, paracetamol or ibuprofen? Do you pop into a shop to buy throat lozenges when you have a sore throat? Do you like to give yourself a bit of a boost each day with a cup of coffee? Or perhaps you prefer to kick start your day with tea? A glass or two of alcohol to unwind come the evening, perchance? Possibly you smoke tobacco or the odd cannabis joint?

While the last of these sits more comfortably under the banner of a "drug," due to its current (il-)legal status in many parts of the world, it's no more or less a drug from the perspective of science than all the other aforementioned chemical substances that we often take to improve the way we feel.

The whole world is on drugs. The reason this can be said with such confidence is because the dictionary definition of a drug is so broad:

> *"A chemical substance used in the treatment, cure, prevention or diagnosis of disease; or used to otherwise enhance physical or mental wellbeing."*

This definition goes way beyond an antibiotic, anti-inflammatory or antidepressant prescribed by a doctor, not to mention a whole plethora of remedies available over the counter at the local pharmacy. Pretty much anything you put in your mouth, or inhale, that changes the way you feel, fits the bill.

Our history of eating, brewing and smoking leaves, shoots, roots, berries, buds and herbal mixtures with a view to making life more bearable or pleasurable predates the invention of the wheel by thousands of years. While the medicinal herbs found in the possession of a man who lived 5,300 years ago suggests we've been on drugs for ages, a real concern these days is the various newfangled drugs that healthy people are starting to rely on, not just to improve their health but to boost their cognitive performance as well. Nootropic compounds, or "smart drugs" as they are usually referred to in the media, are generally taken with the aim of increasing alertness and mental stamina or to maintain cognitive capacities when sleep deprived.

Numerous new chemical substances have popped up in the past couple of decades, which enable already fit and able people to achieve more, both physically and mentally. The trouble is, because they're so new, we have no idea what the long-term consequences of using such chemicals might be. The considerable pressures to study, work and play harder than ever before, just to keep up with the breakneck pace of life in the 21st century, are driving more and more people to give taking them serious consideration. Anyone tempted by the lure of these "chemical assistants" would be well advised to fully understand the pros and cons before they take the plunge. Forewarned is forearmed.

On top of the world

The list of chemicals routinely self-administered with the express goal of improving physical capabilities is vast. We have all heard about controversial track and cycling stars who cheat by illegally dosing themselves with performance-enhancing drugs to increase strength and stamina, anabolic steroids to increase muscle mass probably being the first to spring to mind.

We know from the previous chapter how another hormone – cortisol – works, so you'll not be surprised to hear that anabolic steroid hormones can also have a profound effect, not just on the body but also the brain.

"'Roid rage" is a term associated with people who overdo steroids. As you've no doubt guessed, these people have a pretty short fuse. Taking anything as powerful as a hormone without a prescription and guidance from a medical professional is always likely to end in tears. This is one of the reasons why using anabolic steroids without a prescription is illegal. Under different circumstances (i.e. when prescribed for people with conditions that cause muscle wasting), exactly the same substance is perfectly legal.

Cocaine is an illicit recreational drug notorious for its popularity with rock stars, models and actors, but it's increasingly being used by everyday people from all walks of life, often to fuel wild parties and late-night booze binges. Yet the humble coca leaf – the raw material that is highly processed and concentrated to produce the infamous white lines – has been quietly and responsibly consumed for many centuries by various indigenous cultures living high in the Andes with very different goals in mind. A single leaf can be brewed for consumption as tea (known locally as maté de coca) or simply chewed to extract the juices to settle a bad stomach, to immediately eliminate the symptoms of altitude sickness or to increase stamina to help workers lug heavy stones around at oxygen-depleted high altitudes (to build grand, sacred, religious sites like Machu Picchu and the rest of the architectural wonders that comprise the Inca Trail).

The use of coca leaf in the Incan culture was once reserved exclusively for religious ceremonies and the royal family. Before long, Incas of all castes and classes were allowed to chew it in order to enjoy its mildly euphoric, appetite-suppressing and stamina-bolstering effects.

My cup of tea

In 2005, I did a lecture tour across North America to present my PhD brain scanning studies at several universities and then spent some time travelling around South America as a reward to myself for completing my doctorate.

(Continued)

As Sod's Law would have it, I ended up arriving in Peru during the only month of the year when they shut down the Inca Trail for cleaning and maintenance. Undeterred, I took a train to the foot of the mountain on which Machu Picchu is perched so that I could at least take a peek at the Inca Trail's crowning glory. While I'd spent a couple of days in Cuzco, as recommended, to acclimatize to the high altitude before going even higher, the morning after I arrived at my final destination I still woke up feeling dizzy and nauseous. Despite not really feeling up to it, I headed to the main street to see if I could get some breakfast in me. After explaining to the waiter my need for a very simple breakfast of just plain toast, he refused to accept my order of a black coffee, insisting that I try maté de coca instead.

Having spent much of my teens and twenties partying all over London, I've turned down cocaine on countless occasions. My reasoning has always been that if I've never tried it then, with no personal previous experience of how it will make me feel, the temptation will always be pretty effortless to resist.

Despite my reluctance, the waiter insisted that a cup of coca tea couldn't reasonably be compared to a line of coke and that it was the perfect cure for all the symptoms of altitude sickness I was clearly suffering. Eventually I gave in and he was absolutely right. The dizziness, fatigue and nausea evaporated instantly, after just one sip, and were replaced with a gentle euphoria. Needless to say, for the rest of my trip, whenever maté de coca was offered at breakfast I went for it without hesitation. And happily, when I got back to Blighty, turning down lines of coke continued to be a piece of cake. Phew!

– Jack

When it was first brought back from South America to Western Europe, coca leaf was soon purified into cocaine extract and prescribed by doctors for a variety of ailments. It was even championed by Sigmund Freud,

Queen Victoria and the Pope, no less! Before long, though, the negative aspects of the highly concentrated form of coca reared their ugly heads (namely addiction, heart problems, psychosis, etc.) and so it was swiftly outlawed.

In its unconcentrated, natural form it is still commonly and legally cultivated and consumed throughout South America. Yet in its highly concentrated form, cocaine (and its more lethal cousin crack) causes all sorts of chaos all over the world. It can hijack the habit-forming areas of the brain to cause addiction and trigger the criminal behaviour often required to fund a never-ending need for more of a substance that the whole Reward Line has been thoroughly remodelled to seek more of. Regularly taking cocaine or crack over long periods of time typically leads to psychosis: the person struggles to distinguish between what's real and what's imagined, often involving paranoid delusions.

The point here is that many drugs in their less potent natural form can be enjoyed and exploited for their ergogenic (work-promoting) properties without causing major problems, but once the potency has been dramatically increased with a bit of chemical or biological tinkering, the same drug can wreak havoc in a person's life and in society as a whole.

Not so smart drugs in schools

A new phenomenon of drug abuse is sweeping our schools and universities. And we're not talking about hedonistic youngsters sneaking around looking for a quiet place to have a crafty cigarette or spending their weekends popping pills at parties. The high achievers are at it too and they're not after the cannabis, speed, ketamine, ecstasy, cocaine or psychedelics that the previous generations were keen on. The youths in question are more interested in doing anything to improve their academic prospects by getting their hands on the so-called "smart drugs." Anonymous surveys have revealed that the two top motivations for taking smart drugs

have nothing to do with getting high and everything to do with getting higher grades. They are:

1. Gaining the competitive edge over peers

2. Making mundane tasks seem less boring to increase productivity

Studious students are buying the prescription amphetamine known as methylphenidate (aka Ritalin) from fellow pupils who have been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). The ADHD kids benefit from this drug therapy as it helps them to concentrate and focus better on the task at hand. Highly inflated prices are paid on the scholastic black market with the aim of being able to study for longer and get more work done overall, to convert some of those stray Bs into As. When it seems like "everyone else is doing it" there is inevitably a perceived pressure to follow suit so as to not miss out.

That many ostensibly "good" kids are finding themselves compelled to illegally acquire prescription drugs that might help them to outperform their peers at school is disturbing for several reasons. It's worrying that healthy children are putting prescription-only pharmaceuticals into their systems without much consideration for whether it is safe *for them* to do so. First, there are the twin threats of a whole range of potentially dangerous interactions with other medications that they might already be on *and* the high likelihood of getting the dosage wrong. Another concern is that during the adolescent years, young brains are going through a huge upheaval, as the immature brain is gradually remodelled into its mature state. The worry is that the sporadic appearance of methylphenidate in their systems as exam time approaches could interfere unhelpfully with various aspects of this critically important process.

A further concern is that upping the prescribed dose, which often happens when drugs are taken without proper medical advice, leads to euphoric effects due to interactions with the dopamine-driven pleasure pathways of the brain (the Reward Line). At higher-than-prescribed doses, methylphenidate can end up being highly addictive.

When the same drug is prescribed for those diagnosed with ADHD, it's argued that the benefits they gain from being able to focus their minds and concentrate for longer periods of time (helping them to avoid falling behind in their work) outweighs the possible negative consequences. Indeed, untreated ADHD is often associated with poor educational outcomes and a high dropout rate, which sadly prevents many of these children from reaching their true potential. Treatment for them, on balance, is deemed worthwhile.

The upshot is that there are differences in how methylphenidate affects the brains of healthy people versus those who have a brain disorder like ADHD. When, for example, methylphenidate is used to treat ADHD, improved sustained attention is not the only benefit; their characteristic impulsiveness and love of risky behaviour is tangibly reduced. On the other hand, when taken by anyone who doesn't have the symptoms of ADHD, quite the opposite effect is induced.

Good drug, wrong brain

In one experiment, 40 ADHD-free healthy women were dosed up with methylphenidate and asked to make a series of decisions of varying degrees of riskiness. All of them opted for the wildly risky choices, the financial consequences of which proved to be disastrous!

Whistle while you work

Studies have investigated the effect of methylphenidate on healthy adults using it for nonmedical and purely self-enhancing purposes, such as to improve productivity in the workplace. When asked about its appeal, participants said that they feel more alert, attentive and energetic. There's very little in the way of objective data to support these impressions, but all the same it seems to be accompanied by a mild positive effect on visual working memory and planning abilities.

One major potential drawback is that while it did seem to increase productivity in routine work (i.e. the stuff that can be done more or less on autopilot), there was some evidence to indicate a slight suppression in creative thinking. So while it might help people to pore over spreadsheets for long periods of time, it's more likely to block rather than yield any Eureka moments.

It's not just overzealous kids dabbling in the black market for methylphenidate. Turns out that their hypercompetitive parents might be at it too! In an anonymous poll of 1,400 readers of the prestigious scientific research journal *Nature*, 20% admitted to taking some form of smart drug in an effort to improve their work stamina. Around half admitted to using methylphenidate and many others had experimented with modafinil.

Modafinil was approved by the USA's Food and Drug Administration in 1998 for the treatment of narcolepsy – a troublesome condition where people find themselves falling asleep at the drop of the hat, wherever they are, whatever they're doing, which, as you might imagine, can lead to some very dangerous situations. It has since been tested extensively in the military, going on to become an extremely popular smart drug among civilians and soldiers alike, typically used to stay alert when jet-lagged or sleep-deprived after long shifts.

Modafinil has been tested extensively in people free of any known pre-existing medical conditions. Military studies demonstrated that staff who had been kept awake for 40 consecutive hours felt much more alert and able to function effectively after taking modafinil. In another study, a single dose of modafinil was given to medical doctors at the end of a long shift. They felt that they worked more efficiently with a notably enhanced ability to focus attention. Their decision-making also proved to be more carefully thought through and less impulsive.

Modafinil seems to have a positive impact on decision-making when a person is tired, by enabling users to consider their options more carefully. For this reason it has been investigated as a possible therapy for problem gamblers. Interestingly, gambling seems to become less attractive as a

pastime while under its influence. And if people do go ahead and gamble anyway, it seems to reduce their soft spot for the riskier decisions.

Positive impacts on decision-making aside, it seems that the main allure of modafinil is that it helps people to keep going under cognitive duress and extended fatigue, improving attention and memory under these circumstances – an attractive proposition for many people in the workplace to whom it seems that modern work-life balance is forever tipping towards yet more work.

Nootropic drugs: big dilemmas, grave outcomes

The use of smart drugs by everyday people has been dubbed "cosmetic psychopharmacology." The world of cognitive enhancement, as the phenomenon of off-label use of pharmaceutical agents like methylphenidate (aka Ritalin) and modafinil (aka Provigil) for performance enhancement and sleep avoidance is also known, has skyrocketed over the past couple of decades.

This has led to new moral dilemmas. Some medical doctors have said that they feel ethically obliged to take some form of smart drug when their punishing schedule leaves them feeling fatigued and somewhat compromised in their ability to make critical life-and-death decisions. They consider it their duty to reduce the errors that inevitably creep in due to sleep deprivation by taking drugs like modafinil to improve concentration and alertness.

Doctors in the USA have also complained that they are coming under increasing pressure from patients to dish out prescriptions for smart drugs to help healthy patients keep up with the incessant demands of increasingly competitive work, academic and social environments.

This may look reasonable at first glance, but the upshot is that it's simply illegal for these drugs to be prescribed under either set of circumstances. Irrespective of the legal standpoint, it risks some potentially dangerous

health issues and opens up a whole can of worms in the social consequences department.

In sleep-deprived individuals, a single dose of modafinil does have a strong positive effect on executive function and memory, an effect that gradually wears off with continued sleep deprivation. Yet were they to take the same hit when *not* sleep deprived, they would experience the opposite effect – it can actually induce drowsiness under such conditions. Furthermore, repeated doses of modafinil when *not* sleep deprived increase both positive *and* negative emotional states. In other words, you feel slightly happier, but also more anxious at the same time!

One of the biggest problems with these newer smart drugs is that, in the overall timescale that we humans have been dabbling with mind-altering substances, they really haven't been around for very long. This means that we can't possibly know what the potential negative consequences might be when people have been relying upon such chemical supplements on a regular basis for many decades. That said, there are many other substances out there that we've been consuming for centuries and so the long-term consequences are much better characterised. People wanting to give themselves a performance boost with smart drugs will be on much safer ground, in terms of avoiding some potentially awful long-term consequences, if they stick to the old favourites rather than making guinea pigs of themselves by trying the new kids on the block.

The original smart drug

There is another stimulant drug that raises levels of alertness when fatigued. It does this primarily by blocking the influence of synaptic messenger molecules that suppress the triggering of electrical messages sent down all your brain wires and which accumulate the longer you've been awake. The net impact of blocking this influence across the whole brain is that your senses feel sharpened, reaction times are accelerated and mental stamina is increased.

Similar to methylphenidate and modafinil, this wonder drug doesn't really make you smarter per se; it simply helps you carry out routine

behaviours more efficiently. Beyond these immediate effects, it turns out that this miraculous drug even protects against several illnesses of body and brain that tend to strike later in life. Moderate daily doses throughout middle age seems to confer protection against Type 2 diabetes, liver problems, Alzheimer's dementia and even Parkinson's disease.

So, what is this wonder drug we are talking about, a compound that not only increases brain efficiency in the short term, but also protects against several horrendous medical conditions in the long run?

Well, ladies and gentlemen, get the bunting out and cue the drum roll, please. The name of this original smart drug is. . .caffeine. That's right, common-or-garden caffeine.

Caffeine is a receptor blocker. It clogs up the receptors so that the neurotransmitter adenosine can't get into the receptor to do its work of suppressing electrical message transmission and, as a consequence, "disinhibition" takes place. Blocking the inhibitory effects of adenosine makes brain cells across the whole brain *more* active by, in effect, taking the chemical handbrake *off*. This has an impact on many different messaging chemicals that bridge the synaptic gap between one brain wire and another, including dopamine, glutamate, noradrenaline and acetyl choline, to name but a few.

Full of beans

Caffeine increases levels of the excitatory neurotransmitter glutamate on the Reward Line, accounting for the pleasure people derive from drinking coffee. Like all good things though, we can have too much of it. Overdoing caffeine means inducing so much disinhibition in your basal ganglia – the brain hubs involved in initiating movements – that you end up getting the shakes.

Given the brief time that modern-day smart drugs have been on the scene (and the insufficient long-term safety data that goes with it), if you're in need of a pick-me-up, it's probably best to stick with a smart

Variation in elimination

Lifestyle factors can have a powerful impact on how caffeine is metabolised and its effects on an individual's brain function. Smoking tobacco doubles the rate at which caffeine is removed from the body and so the effects are shorter lived in smokers than nonsmokers.

Conversely, in women using the contraceptive pill, caffeine remains in the system for twice as long as usual, so each dose of caffeine has a longer-lasting effect. That also means successive doses build up to higher overall concentrations; so it's more likely to induce the jittery side effects.

drug that has a proven track record. This is particularly the case for adolescents, where the risks of undesirable side effects are even greater due to the massive overhaul their brains go through during the teenage years. It would be wise, wherever possible, to avoid any disruption to the course of this natural process of neurodevelopment that can be so fraught with challenges even without any further complications from having potentially troublesome novel chemical compounds in the mix.

Caffeine has been around for a long time and with an estimated 50% of the world's population regularly drinking coffee, the risks involved are very well understood. As with all legal drugs, as long as you are careful to keep your daily dose within the low to moderate range (1–5 cups per day) and get all that coffee drinking done by midday so that it doesn't interfere with your sleep, the risks are extremely minimal.

If regularly taken in moderation (3–5 cups per day) throughout the midlife years, there are also significant gains. From the brain's perspective the promise of delaying the onset of nasty conditions like Alzheimer's dementia and Parkinson's disease by five to ten years compared to those who abstain from the magic bean is extremely promising. Curiously

science has not yet discovered the mechanism by which these miraculous neuroprotective effects take place. Some theories suggest that it's thanks to all the antioxidants contained within coffee that mop up the free radicals that otherwise ransack our cellular machinery.

Brewing for survival

Our ancestors were probably first accidentally introduced to booze when thirst or hunger drove them bite into foods like apples, pears, honey, grapes or cereal crops after yeast spores happened to have landed on them and spent some time converting the sugars into alcohol. If you've ever seen wasps getting so drunk on rotting fruit in the late summer that they can't fly straight, you'll be able to imagine how common accidental drunkenness must have been in ancient times.

> If your skull was used as a drinking vessel it would hold about three pints.

The desire to repeat the agreeable feelings of physical and mental looseness that result from mild intoxication would have provided ample motivation to seek the experience out on a more regular basis. Before you knew it, we'd figured out how to ferment these juices intentionally, leading to the wide variety of ciders, meads, wines, spirits and beers, all now readily available whenever we wish to put ourselves in a more relaxed frame of mind.

As a poison, alcohol was able to kill off the various pathogens found in the water supply that might otherwise have led to sickness and possibly death. Early people with a penchant for alcoholic beverages would have had a survival advantage over their teetotal peers. The alcohol in their drinking water made it safe to drink and this helped our ancestors to survive for long enough to reproduce.

Alcohol is not just poisonous for many bacteria and parasites. If we were unable to break it down it could poison us too. Fortunately many of our ancestors happened, completely by chance, to possess a liver enzyme capable of breaking down the toxic alcohol – alcohol dehydrogenase. Those in possession of this enzyme could enjoy the benefits of disease-free water without succumbing to the damage done by the alcohol itself. The ever-presence of alcoholic beverages in the diets of many Caucasian peoples thus favoured the survival of those whose livers could produce this enzyme.

Elsewhere, particularly in certain parts of Africa and Asia, the solution to making water safe to drink was to boil it. As plain boiled water tastes pretty horrible, the addition of berries or leaves to the brew became commonplace. And thus the habits and rituals of coffee (berries) and tea (leaves) drinking were born.

The daily drinking of toxic alcohol is made safer by the gene that allows the human liver to produce alcohol dehydrogenase, which most people of Caucasian descent possess, but many of Asian origin lack. But as the chemical substances in tea and coffee are *not* poisonous, anyone can enjoy them safely regardless of their genetic makeup.

What is a hangover?

Your kidneys are constantly at work squeezing all the juices out of your blood as it is forced through millions of tightly coiled blood vessels. Everything you don't need, such as the waste products of metabolism, are passed onto the bladder so that you can be rid of it. Water, on the other hand, is selectively reabsorbed back into the bloodstream across special channels that can be opened and closed to ensure you stay adequately hydrated. Unless, that is, you have alcohol in your system.

Alcohol paralyzes the special channels that reabsorb the water back into the blood, clamping them shut. So the water that was squeezed out of the blood as it passed through the kidney cannot get back into the bloodstream, instead passing on down to the bladder with everything else. This is why you urinate more when inebriated and it's also the reason that the more you booze, the more dehydrated you become. You simply cannot keep the water you drink inside you for very long when there's lots of alcohol knocking around.

While your brain itself has no pain receptors, there *are* pain receptors in the three-layered sack in which your brain resides – the meninges. When you're dehydrated these layers all press together, squeezing and switching on the pain receptors within. That's where the pounding headache comes from. Rehydration is the best cure for a hangover, but the solution is not always as straightforward as drinking plenty of water.

If your drinking session got all hot and sweaty then you'll have shed lots of salts in your perspiration. Even in the absence of alcohol, your kidneys can only do their job of reabsorbing the lost water if they are chock full of salts. The fact that your kidneys can't work properly if they

(Continued)

are salt depleted explains why people crave salty snacks when drunk. A glass of rehydration salts before bedtime might be just the ticket to take the edge of the headache, by helping the kidneys rehydrate your blood and juice up those meninges to avoid a nasty hangover.

Changing perspectives

Psychedelic drugs like magic mushrooms (various species of which have been taken by humans for aeons) and LSD (a relative newcomer, first synthesised in Switzerland in 1938, but only consumed – completely by accident – five years later) have both come under increasing scrutiny in recent years, as scientific interest in their potential therapeutic benefits have become reinvigorated. The reason is that they seem to have a tremendous and profound capacity to change people's perspectives, something that can make a huge difference to people trying to get their mental health back on track.

There is much interest these days, particularly in Silicon Valley, in the potential for microdosing psychedelic compounds to help with creative thinking and problem solving. The idea is that people take a dose so tiny that they don't feel any obvious effect of the drug, but there is still a subtle subliminal effect on thinking patterns.

At the moment the research into this possibility is still trying to establish how "micro" the microdose should be. So far, all the studies have a different definition of how much should be taken and there are ambiguities over how much active ingredient is in any given microdose, so results are inconsistent. Until the research community gets all their ducks in a row, the truth as to whether microdosing makes the blindest bit of difference to creative output will remain shrouded in mystery.

Perspective changing is extremely important in conditions like major depression because many people who struggle with this extremely bleak

ailment often find themselves held back by deeply troubling past experiences. A completely fresh perspective seems to make their unpleasant past life events easier to live with. As the drugs conventionally used to treat such conditions are notoriously hit-and-miss, there's a great deal optimism about the resurgence of clinical trials that are currently picking up where scientists of the 1960s had to put down tools when psychedelic substances were suddenly outlawed.

Powerful mind-bending substances like psilocybin (the active ingredient in magic mushrooms) can take people to scary places in their imaginations, so the clinical trials involve taking it in a safe therapeutic setting – with the support of both a psychiatrist and a clinical psychologist to provide expert guidance when the experience gets hairy. This helps to ensure that the trip does more good than bad overall. The early evidence indicates that even people who have suffered with depression for decades can experience long-lasting, profound, positive changes in how they think about themselves and their life in general.

Having revisited traumatising past events under the influence of such psychedelic compounds, many patients find that they start to view their troubles differently and start to feel something like their old selves again. While the drug only stays in their system for a few hours, the benefits they experience may last for weeks, months and in a few cases even years!

Zero to hero

For decades, several drugs known for their recreational use – not just magic mushrooms, but also agents like ketamine and ecstasy – were thought only to *trigger* mental health problems. These exact same substances are now shaking off their bad reputation by proving to be extremely effective (according to recent clinical trial data) in treating obsessive compulsive disorder, alcoholism, major depression and post-traumatic stress disorder, often under circumstances where patients had previously seen little-to-no benefit from more conventional drug therapies.

It is important to note that, at the moment, these studies are still figuring out the details regarding what the best doses are and who might benefit from these approaches the most. And before you start planning your next mushroom-picking excursion, please bear in mind that the experience of being on these substances was extremely harrowing for many of these very unwell patients. Without the counselling of highly qualified, trained professionals to guide them through some of the scary things that can occur while on these substances, it might well have made their condition worse, not better. Please don't fly solo. Wait for psychedelic psychotherapy to become available through conventional means.

Fixing up the wear and tear

The longer a drug has been around, the more we know about its long- and short-term effects. Yet the newer smart drugs like methylphenidate (Ritalin) and modafinil (Provigil) are becoming increasingly available for nonmedical purposes. Their use in schools and workplaces is on the rise.

We might not know yet what all the outcomes are of taking these substances over long periods of time, but what we do know is that taking any pharmaceutical without medical supervision can potentially lead to dangerous, unnecessary health risks. This is partly due to the high likelihood of damaging interactions with other prescribed drugs, if smart drugs are taken at the same time. It might render the prescribed drugs ineffective, inadvertently increase their potency and in some cases produce toxic side effects.

The upshot is, if you do feel the need to rely upon chemical assistants to help you keep up with your busy life, if the substance you're considering hasn't been around for a very long time and hasn't actually been prescribed to you by a medical health professional, you're always going to be playing "neuro-roulette" – no matter what anybody tells you.

Chapter takeaways

- Got a hangover? As well as drinking plenty of water, you may also need to replace lost salts to help your depleted kidneys put the water back in your bloodstream.

- It is humankind's meddling that gave the humble coca leaf such a bad name. In its natural form and in moderate quantities, it's actually pretty harmless. The concentrated forms, on the other hand, are dangerously addictive and potentially lethal.

- The latest smart drugs may be great for people with prescribed needs, but for those just looking to up their performance, they might *not* be the intelligent choice in the long run.

- If you're in need of a little brain optimization and want something that's legal and has a proven track record, caffeine's your best bet.

- If coffee's not to your taste, black tea has a drug in it that's very similar to caffeine, but with 50% of the potency. And green tea has just 15% of the stimulant potency of coffee.

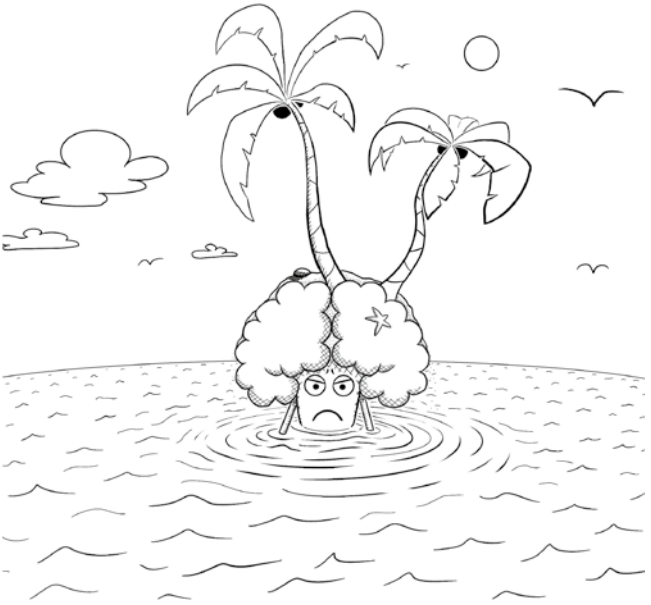
- Thank your ancestors' ingenious use of alcohol, coffee or tea that you could be here today!

Get Yourself Connected

"It's not *what* you know, but *who* you know."

This phrase is often dusted off and wheeled out to draw attention to those who have "old school tie" connections that seem to give them an unfair advantage in life. But that's just one tiny aspect of the countless benefits we *all* get from having people in our lives we feel we can trust, whoever we are and whomever we know.

As the most social species on the planet, our brains only *really* thrive when we feel part of a social circle – *any* social circle, not just the influential ones. It really doesn't matter if that network is family, friends, colleagues or neighbours; having a few people in our lives that we genuinely feel accepted by has a disproportionate effect on our well-being. So any time spent securing our relationships, by checking up on each other or helping each other out, is time well spent. If we end up feeling valued by several social groups – well, that's even better, because the advantages multiply. No man, or woman, is an island.



Married women live, on average, two years longer than their unmarried counterparts, but men seem to get an even better deal. Married men get a whopping seven bonus years of life compared to lifelong bachelors. It's almost as if our other halves give us a reason to live!

Some of these benefits are obvious, like having people around who might be willing to help us out from time to time, providing emotional support or practical assistance when we find ourselves in need. Other benefits are not so obvious, like the importance of including people in our social life who are different from us, in order to broaden our perspectives and realise the "wisdom of the crowd" in all its glory.

Help, I need somebody!

We all know that there's safety in numbers. For millions of years each successive generation of our ancestors managed to become accepted members of a group and so became more likely to survive than the antisocial loners, who had a distinct tendency to die off before managing to pass on their genes. So baby brains evolved to start off with a few basic social skills and then gradually acquire many more over the course of childhood, helping them to fit in better and better with other people for the long-haul.

Humans probably started cooperating with each other in the first place to make hunting larger animals possible and make rearing their perpetually vulnerable offspring a team effort. While a lone human could bring down a bird or trap a rabbit with little difficulty, felling a woolly mammoth required larger teams able to coordinate their efforts.

The most likely technique was to chase it for many hours across the plains and then skewer it once it had collapsed with exhaustion. Once an eight-ton beast had been felled, an army of people would then be needed to quickly butcher the meat and then either preserve it or eat it, before it went off or dangerous scavengers caught the scent. Once our ancestors started cooking their meals, there was yet *another* reason to come together on a regular basis – to share the meal and "get it while it's hot."

Our childhoods last longer than any other animal on planet Earth. For many long years you were *completely* dependent on others to look after your basic needs. During this time you required an adult (ideally a parent, or better still two) to provide the food, shelter and protection necessary for your survival. Your life literally depended on having an innate ability to motivate others to support you.

One thing that helped were your big eyes or at least eyes that appeared to be large compared to the size of your head. This is one of the reasons we find young animals so cute. And this cuteness unlocks our caring instincts. Similarly, a crying baby is very difficult to ignore and for good reason. The pitch of a baby's wailing is perfectly positioned in our hearing range to be detected far and wide; plucking at the heartstrings of anyone within earshot. Most adults hearing this sound will usually feel perturbed by the distressing sound and so find themselves motivated to try and offer some support, even if just to spare their ears further discomfort.

Then, over the course of childhood, most of us rapidly and effortlessly pick up a dizzying variety of social abilities. Exploration and interaction with the outside world enabled your sensory, movement and speaking abilities to develop in leaps and bounds. All the while a variety of adults – not just immediate family, but teachers, neighbours, friends' parents and carers – helped to ensure that, as much as possible, the urge to explore didn't end in tears. As they say, it takes a village to raise a child.

In one particularly memorable study, a bunch of two-and-a-half-year-old infants were pitched against fully grown adult chimps and orangutans. While their cognitive abilities were well matched in many regards – such as their ability to work out where delicious treats had been hidden and using tools to extend their reach when their arms weren't long enough – the human infants were *much* better at two key social skills. Their abilities were superior in terms of being able to track people's eye movements and working out what other people were trying to do just by watching them.

Bit by bit over the course of adolescence, the final pieces of the brain jigsaw fitted into place and you finally reached adulthood. Having tested the waters of independence over the teen years, moving in and out of different social circles and slowly but surely reducing reliance on parents or carers, eventually the chick you started out as was ready to fly the nest.

Mind readers

To fully develop our social potential, as children we needed plenty of opportunities for social interaction, to hone and finesse the brain pathways supporting these fledgling abilities through trial and error. This includes almost half the tissue on the inward-facing surface of your brain, regions like the medial Prefrontal Cortex (mPFC stop) and various parts of the Cingulate Cortex. Many brain regions scattered across the outward-facing surfaces are involved too, including several stops in the Temporal, Parietal *and* Frontal districts that help you to interpret eye movements and body language. Assuming the absence of neurological conditions like Autism Spectrum Disorder that can interfere with this process to one degree or another, the vast majority of people end up able to read other people's minds!

There's nothing supernatural about this mind reading. It means being able to work out what other people are thinking, or at least what goal they are trying to achieve, just by noticing how their eyes move, their tone of voice and how they move their body from one moment to the next. Our brains use many subtle tricks to help us put ourselves into other people's shoes, to see the world from their perspective. This helps us to pick up on whether our own behaviour pleases others, or rubs them up the wrong way, making it much easier to become an accepted member of a new social group or to remain part of an existing one.

By adulthood, these incredible mind-reading skills are so second nature that we hardly notice them, mainly because they take place almost completely subconsciously. We often can't explain *how* we know what another person is thinking or feeling; we just do. We can *just tell,* when deep down a family member is feeling really put out even though they're pretending to be fine with the turn of events. We can *be sure* that a colleague is secretly delighted to see a sworn enemy getting a public dressing-down from the boss, despite doing their best to hide their glee. And we can have a *hunch* that a friend is feeling frustrated not to have gotten their own way, despite their insistence that they're "really not bothered."

All this mind reading is incredibly important when it comes to staying in people's good books. It helps us to adjust our own behaviour in light of their *true* feelings, rather than the emotions they are projecting to hide their blushes.

Emotional broadcast

When someone is feeling happy, sad, scared, angry or disgusted, it's usually written all over their faces, quite literally. You could pluck somebody from anywhere in the world, show them photos of people pulling the distinctive facial expressions associated with these *universal* emotions and they would instantly know exactly how that person was feeling.

That's because all humans have the same 42 muscles embedded under the skin of their faces, which *automatically* pull different facial expressions when we're feeling each emotion. These, together with telltale body language signals, give people around us a better idea of how we're feeling, which may or may not tally with what we're saying about how we feel. This gives others in the group a useful heads-up about whether or not it is a good time to approach us.

If you have a big smile on your face you will seem more approachable, because happy people tend to be open to interacting with others, even strangers. But if you're frowning, perhaps because you're lost in thought, fuming about something somebody said to you, that look on your face will discourage people from disturbing you for fear of ending up on the receiving end of your wrath. Reading emotions on people's faces enables us to better predict the outcome of social interactions.

A sad face tends to inspire sympathy – everyone knows how horrible it feels to be upset and that knowledge naturally compels a social creature like the human to consider offering some comfort. If that person acts on this urge, it might not just help to cheer the sad person up – a benefit all by itself – but it might even help to form a closer bond between the two

parties, setting up more opportunities for mutual support in the future. Any act of kindness is likely to result in gratitude from the recipient and that gratitude will usually result in efforts to return the kindness.

Facial feedback

Emotions are contagious. When you catch sight of a happy-looking person, this rapidly and fleetingly makes you feel happy yourself. Within about three- to five-hundredths of a second, our own faces will automatically mimic the same expression as the other person by very briefly triggering contractions in our own facial muscles. During the moments that our own faces pull a matching facial expression, we feel the *same emotion* that they are feeling. The ability to feel the emotions that other people are feeling is called "emotional empathy" and is a key part of our ability to read other people's minds.

People who get Botox in their forehead to remove worry lines become less angry, because the process involves paralysing their frown muscles. Strange as it may sound, if you can't physically pull the appropriate facial expression, you can't feel those emotions as powerfully.

While this might sound great, there is a drawback. The inability to pull frowning facial expressions means that these people struggle to detect anger in other people's faces too. And that could lead to some tricky situations!

Several different brain areas are specialised to process all the relevant sensory information to perform these incredible feats of emotional empathy. One important part is on the outer surface of the brain where the Temporal and Parietal districts meet (TPJ stop) and another is the medial Prefrontal Cortex (mPFC stop) on the inward-facing surface of the brain just behind the forehead.

The amazing emotion-detecting skills of these regions are not just limited to the six universal emotions of happiness, sadness, anger, surprise, fear and disgust. A recent brain imaging study showed that they can also distinguish between dozens of other subtly different types of emotion, from gratitude to embarrassment and from nostalgia to loneliness.

Rapport radar

The *universal emotions* like happiness or sadness can affect us with or without the company of other people, but the *social emotions* – like pride, envy, guilt and shame – are specifically produced in response to interactions with others. While the universal emotions are triggered in response to similar kinds of experiences, wherever in the world you grew up, that's not true of the social emotions. That's because the rules governing which behaviours are and aren't acceptable to the people around you change dramatically from one culture to another.

What causes shame in one culture may be source of pride in another. For example, bragging about achievements is positively encouraged in some parts of the world, but considered repulsive in others. As your own childhood progressed, you slowly but surely picked up on the standards of behaviour expected by your elders and the community at large.

Pride makes us feel good when we behave in a way that earns us praise from others, making us more likely to repeat those behaviours in the future. Shame makes us feel bad when we fail to meet up to expectations and makes us more likely to avoid those behaviours from then on.

Whatever the rules of engagement were in the culture in which you were raised, these social emotions guided you by reinforcing certain behaviours and discouraging others. This allowed you to gradually adjust your behaviour to match people's expectations so that, once you became an adult, you wouldn't find yourself being kicked out of the group.

If everyone you know got invited to a party and you didn't, how would that feel? Social rejection really hurts because it causes powerful activation of the dACC stop – part of the "pain matrix" cluster of brain areas. It creates the distress we feel when we stub our toe, but also when we feel snubbed by someone or by a group of people. In other words, it produces feelings of both physical *and* psychological pain.

The psychological pain we feel when our social connections are threatened help us to avoid repeating whatever social blunder led us to fall out of favour in the first place. That we feel pain when others reject us testifies to how important membership of a group was for the survival of our ancestors. And it still is; we truly are pack animals!

Those who do manage to maintain and grow their social connections all the way through childhood into adulthood slowly but surely become better and better at encouraging others to collaborate with them. And it turns out that having others in our lives with whom we feel meaningfully connected is not just nice to have; it actually improves our physical and mental health.

Loneliness kills

When it comes to the scientific evidence supporting the importance of social connections, the writing is on the wall: *get yourself connected*. For several decades now we've known that people who feel lonely, compared to those who do not, have a greater risk of dying of illnesses like cardiovascular disease and certain cancers. Not only that, but chronically socially isolated people are also more likely to suffer with depression, anxiety or personality disorders.

That said, it's not a popularity contest – the physical and mental health benefits of being socially connected don't require a huge social network. On the contrary, having just one or two people we can really rely on when we need advice or cheering up, with whom we can share our hopes and fears knowing that it will remain confidential, is perfectly sufficient.

Feeling accepted as part of a group of any kind – and it really doesn't matter whether it's a hobby group, a neighbourhood, a religion, a sports team or a book club – tends to reduce our stress levels, on balance. The feelings of security and comfort that arise when we feel accepted by others are all thanks to the release of a neurohormone called oxytocin, manufactured in the hormone HQ – the hypothalamus – and transported to the pituitary gland stop from where it's squirted into the bloodstream. Social acceptance increases our levels of oxytocin, which takes the edge off our stress, making it more manageable overall.

Oxytocin has been available as a nasal spray for the last couple of decades and dozens of experiments have been conducted to work out how it influences our social behaviour ever since. One of these showed that, when people were deciding how to spend their money, they gave more generously to help other members of their own team when given a squirt of oxytocin up the nostril. But, at the same time, they were also harsher in their punishment of competitors. So if you thought that oxytocin only makes us all squishy and cuddly, think again. It actually sharpens the boundaries between friend and foe, making us act more kindly towards the former, but more aggressively towards the latter!

All mammals release oxytocin, from tiny little mice all the way up to big strapping elephants. It's long been known to be vitally important in cementing the first social bond we ever experience – that between mother and child. But its role in bringing us comfort doesn't stop there. Every handshake, every hug, every "pat on the

back" – whether physical or verbal – causes a release of oxytocin into the bloodstream, increasing our comfort levels and diminishing our sense of vulnerability.

Grooming and gossip

Chimps, gorillas and orangutans – all of which, like us, are primates – spend a huge amount of time grooming each other. In some species this accounts for up to 10% of their waking day. They choose whom they groom very carefully because this is what helps them form and maintain their social connections, ultimately establishing their position in the pecking order.

All that grooming helps to remove hard-to-reach bugs and ticks from their fur, but that's not the reason allegiances are formed and broken according to who's grooming whom. It has much more to do with the release of oxytocin. That's because the stress-relieving feelings of increased comfort that accompany each squirt of oxytocin from the pituitary gland become associated with whichever individual was allowed to get close enough to do the grooming that triggered it.

Long ago our ancestors ditched the physical grooming, because we'd developed the capacity to do something that helped us to cooperate in much larger groups: talking. We've been grooming each other with gossip, rather than physical touch, to work our way up the pecking order ever since.

Mental health champions on every high street

Every high street has a shop in which highly trained individuals simultaneously groom hair *and* gossip almost continuously. For this reason, hairdressers and barbers may bring more psychological relief into *everybody's* lives than any other profession.

Gossip allows us to work out who is an asset to any group effort and who's a liability, in any given community, without having to learn the hard way. Social bonds tend to be reinforced with people who provide the type of information that is accurate and useful, but weakened if the stories people tell turn out to be misleading or plain vindictive.

Those with best overview and a reputation for offering a truthful account of what's happening throughout any given social network tend to move up the pecking order. And the main reason we value relationships that provide us with accurate social information is that it helps us to steer away from difficult people and towards those who have a reputation for being trustworthy.

There are always people in life who seem to love nothing more than trying to get away with doing as little work as possible and letting others make up the shortfall. Others take the view that "If a job is worth doing, then it's worth doing properly," which can leave them making up for other people's laziness. This battle between the freeloaders and the conscientious hard workers has been raging for millennia. You might wonder how the freeloaders get away with it.

Well, a selfish *individual* can only thrive if they manage to embed themselves in a *group* of altruistic people – those who are motivated to help others, regardless of whether the favour is likely to be returned. *Groups* of altruists, on the other hand, will always outcompete *groups* of selfish individuals. That's because members of the selfish group are likely to be unwilling to cooperate with each other. They won't get the work done properly and will usually find themselves being outcompeted by the teams who *are* willing to help each other out. Also, freeloaders can only survive if they can land themselves in a team that's big enough for their lazy tendencies to go unnoticed. In smaller teams, they'd simply never get away with it. It would be too easy for someone to call them out.

When people are forced to make decisions very quickly, their decisions tend to be more altruistic. Only when they're given plenty of time to think about it can they override this basic instinct for doing what's best for the group and instead choose the more selfish option. This explains why charity auctions are a great way to raise money for worthy causes!

You disgust me!

When people feel outraged by someone – whether it's a team member who repeatedly leaves everyone else to do all the hard work, or somebody who publicly shames a friend or family member – this behaviour may be described as "disgusting." Similarly we feel "sick to the stomach" when we think about the really unpleasant aspects of antisocial behaviour in our communities – like violent crime – because it threatens our well-being by disrupting the peace.

The sight or smell of rotten food is also usually described as disgusting if it makes us gag, churns our stomach or triggers feelings of nausea – and that's no coincidence. Whether caused by unpalatable foods or inappropriate social behaviour, either way these feelings of disgust are generated in the Anterior Insula stop (see the Outward-Facing Brain Tube Map in the Appendix). You may recall that this brain area also becomes activated when we see a hefty price tag that could be described as "disgustingly" expensive. Feelings of repulsion all come from the same place.

Generally speaking, when we feel disgusted the emotional reaction is telling us to stay away from a source of potential contamination, whether it's physical or psychological. This serves us very well in keeping us safe from harm when it encourages us to steer clear, but it can also lead to righteous indignation about other people's behaviour, which is dangerous territory.

While it takes a lifetime to develop a good reputation, just a few moments of poor judgement can ruin it in one fell swoop. A single episode of "flying off the handle" at someone can damage your own reputation in other people's eyes forever.

Never type angry

You've probably heard the advice: never type angry. When we're in an emotionally charged state of mind we make terrible decisions, particularly when the emotion in question is a negative one like anger. If you absolutely must type angry – to get it out of your system – DO NOT under any circumstances actually SEND IT. (And don't write it as a draft email either or else you might end up hitting send by mistake!)

Come back to it the next day, in a calm state of mind, and ask yourself one question: "What do I hope to achieve by sending this?" There, right in front of you, will be all the evidence anyone could ever want to demonstrate how blurred our judgement can get when in a negative state of mind.

Having reedited the message several times, only send it once you can say to yourself, hand on heart, that you are no longer just venting frustration and that it has a good chance of achieving something useful. Comparing the original with the final draft will help you see how badly anger can cloud your judgement – and potentially ruin your reputation in someone's eyes forever. This is one of the best pieces of advice I've ever had. Thanks, Dad!

– Jack

If everybody contributes to a shared goal equally, all can achieve more together than any one person ever could manage alone. But if one person is forever shirking their duties and leaving everyone else to do all the hard work, this will inevitably lead to friction. So how to keep the numbers of people who don't play fair down to a manageable level without the direct conflict that might damage your own reputation? By sharing this information with others – in other words, gossip.

While the word "gossip" is usually used to describe the exaggerated, shocking and perhaps entirely fabricated information that gets circulated with the specific aim of maliciously damaging someone's reputation, there is a milder form that serves a purpose that benefits everyone. Sharing information about who can and can't be trusted can be a very effective way of undermining people who don't play fair, without the need for a big, ugly face-off. And when we receive information that helps us to avoid a nasty experience, we usually feel incredibly grateful to whoever helped raise our awareness of the potential prickly situation.

There's that word again: grateful. Trust and gratitude are the lifeblood of social networks. If you feel grateful to someone for sharing a useful nugget of social information with you, you'll naturally want to try to repay the favour. And multiple exchanges of favours build trust and strengthens social bonds.

Nurture your networks

Many people think of their social connections as being nice to have, but not particularly important in the grand scheme of things. But not only are our friends and colleagues fundamentally important to our well-being; they also have a huge impact on our access to all sorts of information. Our immediate friends help us to expand our knowledge – by sharing their own experiences and opinions with us – but our friend's friends are even more valuable in this regard.

People in our immediate friendship group are often friends with each other. They may have grown up in the same area, gone to the same schools, worked in similar industries and so much of what one person knows is also known by most of the others. Friends in the same social group tend to share access to a broadly similar pool of knowledge.

When it comes to the friends of our friends – those people whom we've maybe met once or twice but don't know very well – they're a different matter. They are the ones who have access to different pools of

information, or knowledge of opportunities, that simply isn't available in our closer social circles. The knowledge held by these secondary (and tertiary) social contacts is often extremely valuable, so it can really pay to go out of your way to be on good terms with your friend's friends (and your friend's friend's friends) whether or not they are the type of people you usually enjoy hanging out with.

Research conducted among people who had recently found a new job in the suburbs of Baltimore asked them a simple question: how often do you talk to the person who told you about your new job? While a small proportion said that they spoke to the contact in question regularly, the vast majority said that they spoke to them rarely – attesting to the importance of "weak" as opposed to "strong" social connections.

Birds of a feather flock together reflects the fact that people tend to be drawn to people who look like them, sound like them and *think* like them. This means that the social groups with whom we feel most at home are also the ones from which we stand to learn the least from. Seeking out friendships with people who are different from ourselves, raised in a different part of the country or the world, exposed to different cultural traditions, brought up under a different religious belief system and so on, will naturally see and judge the world differently from the way we do.

A problem that might seem very difficult to solve from the perspective of people "just like us" is often no problem at all when seen through a very different pair of eyes – especially when those eyes are attached to a brain that has spent a lifetime being conditioned by different ideas, expectations and assumptions.

Whoever you have in your social networks, at work and at home, it really pays to stay in regular contact. People who take care to nurture their relationships, in the sense of going out of their way to get in touch more often, respond to messages sooner rather than later and in a way that tries to be maximally helpful (meaning they're doing all the basics that show they care) end up with great advantages.

They soon find that they are able swiftly to bounce ideas off many different people, quickly get back lots of useful feedback and ultimately find better solutions to their problems. Just as we can hone the communication pathways *inside our brains* through regular, intensive and long-term practice, we can also strengthen the communication pathways *between different brains* in our social networks using a similar approach. It's not just who is in the network that counts, but also the willingness of each part of the network to be available to each other when the need arises.

Studies investigating creative thinking in the context of teamwork in businesses have shown that having a few very bright sparks in the group is *not* the key to consistently generating good ideas. The secret is having a *diverse* group of people where each member feels free to communicate their ideas and feedback honestly, openly and importantly, without fear of getting landed with all the work if their idea is considered to be a winner! If one or two people tend to do all the talking, problem solving and innovation are hampered. Leaders who build teams in which there is a genuine spirit of open collaboration and focus on keeping everyone equally involved in the conversation, experience the greatest success overall.

Being more social

Offer to lend someone a helping hand and they will naturally feel grateful towards you. These feelings of gratitude are inevitable because knowing that you were willing to offer some assistance is psychologically reassuring. It induces a squirt of oxytocin into their bloodstream,

enhancing their feelings of security and comfort – a positive impact on their well-being that is directly attributable to you. And this happens regardless of whether or not they actually take you up on the offer. If they do, well, that's even better.

Human brains are extremely sensitive to imbalances and unfairness. To be indebted to others makes people feel uncomfortable. Put the two things together and the result is that most people harbour a strong desire to repay any favour you might do them. So the benefit of helping others for *you* is the reassurance that others might be willing to come to your aid the next time you're in need. And even if that doesn't happen, it still boosts your reputation as someone who can be relied upon and is therefore an asset to any group effort.

Repeated cycles of mutual helping and trading favours is an excellent way not just to create new relationships, but also to test the strength of your existing ones. It can help you to flush out the freeloaders you've been tolerating for too long and reinforce connections with the people who really are worth the effort.

The "Dunbar Number" of 150 people describes the maximum size of a social network that our highly social brains can keep track of. Throughout prehistory, before the invention of laws (and police to enforce them), whenever a group of humans living in the same place exceeded this number, they would split in two and go their separate ways. Why?

In small groups, it is pretty straightforward to keep track of who gets on with whom and which pairs of individuals clash. With a group of three people (let's call them Mr A, Mrs B and Ms C) there are three possible relationships (A-B, B-C, C-A), With a group of five people there are ten possible paired relationships (AB, AC, AD, AE, BC, BD, BE, CD, CE, DE).

When the groups get bigger, the number of relationship quickly become unmanageable. Once you get up to a community of 25 people there are 300 possible relationship pairs. And with a group of 150 people there are a mind-boggling 11,325 possible relationships to keep track of – no wonder *Game of Thrones* got so confusing!

Not everyone plays the game fairly. Building social networks by offering to help people is very much a numbers game. If it starts to feel like a one-way street, with you forever helping someone who always seems to have an excuse at the ready when the time comes to return the favour, then your willingness to offer further assistance will dry up quicker than a puddle in a heatwave. But it is important to give people the benefit of the doubt, at least to start with.

Given that *most* people end up with a brain wired to maintain some kind of equilibrium in the paying and repaying of favours, your investment in helping others *will* pay dividends in the long run. They might not be able to repay the favour in a like-for-like matter, but most people will bend over backwards to do *something* to redress the balance, even if they just bake you a cake or some other minor act of kindness. This approach should eventually leave you with an army of willing helpers at best and, at worst, a great reputation for being a good egg.

From the perspective of brain science, the main benefits of turning up every week at a sports club, religious institution or hobby group has little to do with sporting prowess, gaining access to heaven or honing your craft skills. Instead it has much more to do with gaining the physical and psychological health benefits that result from regularly putting in the effort to forge new social connections and maintain existing ones. Either goal can be achieved by nurturing a positive disposition towards other people, even strangers, and a willingness to help.

Diversity pays dividends

Having a handful of friends and colleagues you can speak openly and honestly with provides an invaluable sounding board off which to bounce ideas, fears and ambitions. Just having one or two people with whom we feel safe and comfortable sharing our private thoughts goes a long way towards helping us move forward because it gives us a fresh perspective. There is no better way to see whatever is on our mind with greater objectivity; just explaining the situation to someone out loud can help, even if you get no useful feedback.

If you can grow your personal social network to incorporate people with different skill sets, backgrounds and personality types from your own, then that's even better. A tricky problem that's been giving you a headache for months can be solved instantly by someone who deals with that kind of thing on a daily basis.

Others are often much better positioned to point out errors or inconsistencies in our thinking. Many of us worry needlessly over things that are either easily remedied or not even worth losing sleep over, but we don't realise it until someone else helps us see the bigger picture.

Equally, their own lifetime experience might suggest that there are other things we *should* be focusing on instead that hadn't even crossed our mind. The point is that we only have one brain with which to try and understand the world, but by consulting many other brains – the more different from us, the better – we can gain the full benefits of the wisdom of the crowd.

Wisdom of the crowd

In 1907 Francis Galton visited the West of England Fat Stock and Poultry Exhibition, where fantastic prizes were up for grabs for whoever could guess the weight of a fattened ox most accurately.

A perpetually inquisitive man, he was curious to know how good the average person might be at making such predictions, so once the competition was over he asked to have a look at the cards on which people had jotted their estimates.

The vast majority were wildly wrong. Some guessed way above the true weight of 1198 pounds and other estimates were ridiculously low. Yet putting all the answers in ascending order he found that the median value – the one in the middle, 1207 pounds – was more or less bang on the money. The point is that many minds working together on a certain problem will invariably give a better answer than one working all on its lonesome.

A problem shared is a problem halved. Many hands make light work. There's an endless list of idioms like this because they are so self-evidently true. The practical side of this is obvious: we get more done together than we ever could alone. But when it comes to psychological benefits we tend not to take such a practical approach.

Two buckets

In conclusion, spending time with people we know we can trust helps us to feel more secure. That's all thanks to increased oxytocin. Feeling secure in our relationships brings down our stress levels and reduces our psychological pain. That's all thanks to reduced cortisol. Imagine you're carrying two buckets, one in each hand. One has all the cortisol that is currently in your bloodstream sloshing around in it and the other contains the oxytocin currently coursing through your brain.

If you're feeling stressed out you can look for opportunities to bring those cortisol levels down to more manageable levels. But that's not always possible. Sometimes we just don't have time to do the rest and play that achieves this goal. If it's not possible to tip some of the excess stress out of the cortisol bucket, then it's time to think about how you might top

up the oxytocin bucket. Pick up the phone and call an old friend. Stop to chat to a neighbour. Offer to help a complete stranger carry their load. Exchange some light banter with the person serving you. Stop to stroke the cat sitting on that wall.

Interacting (ideally in person, but over phone or video chat works okay too) with other people will raise your oxytocin levels and that will take the edge off your stress. And the more you've got in the habit of nurturing your social networks on a regular basis, the more likely there'll be someone available to you when you really need it. When you do meet people to person, don't forget that when you're absorbed by a device, you are effectively not in the room. If they're on their own phone too, neither are they. So keep your phones on silent and out of sight.

Never underestimate the power of a hug when it comes to topping up the oxytocin bucket. Physical affection can be dynamite when you find you're in need of a pick-me-up. Even a handshake does the business. If physical contact with other people is not your bag, the oxytocin boost from physical touch doesn't even have to come from a human. The companionship of a pet is also a great source of oxytocin. And stroking someone else's pet will raise your oxytocin levels too.

People who are at the centre of a social network are happier than those who find themselves out on the edge. And it is being at the centre – surrounded by many other people – that actually makes them happier (i.e. they are not necessarily at the centre because they were happier in the first place). The best way to move towards the middle of a social network is to collect new social groups. That means always being on the lookout for opportunities to join in with group activities.

The more different social circles you collect – walking groups, sports teams, hobby groups, volunteering organisations, music scenes, political organisations, religions and so on – the more options you'll have for filling up your oxytocin bucket. So the next time you feel tempted to cancel your social plans in favour of staying in to watch the box, don't forget that those other people in your life will make you happier *and* healthier in the long run. And strengthening those social bonds means catching up as often as possible.

Chapter takeaways

- Social connections aren't just nice to have; feeling like you are an accepted member of a group is good for your physical and mental health.

- We automatically broadcast our emotions in our facial expressions and body language, which guides others regarding how to interact with us.

- Oxytocin released during positive social interactions – like a hug or a reassuring chat – makes us feel happier and more secure.

- Social rejection is deeply upsetting because it causes activation of the brain area – the dACC stop – involved in producing feelings of physical and emotional pain.

- Most people are instinctively pro-social; when forced to make decisions quickly we usually choose whatever benefits the group as a whole, only behaving selfishly when given time to scheme.

- Offering to help other people is the fastest way to make new social connections. Not everyone will repay the favour, so only continue using this strategy with people who "play fair" and reciprocate your kindness from time to time.

- The maximum size of a "community" that your brain can keep track of is 150 people and it pays to make sure that your social networks are as upbeat, diverse and broad as possible.

Mind over Matter

The stories that you tell yourself are important. They help to shape your beliefs. If you tell yourself stories that help you to believe you can do it, you'll try harder. If you tell yourself stories that make you believe it's all hopeless, you'll almost certainly put in far less effort. Just think of all those elite athletes who point their fingers or palms up towards the heavens at important moments during big events – telling themselves stories that help them to achieve great things.

The stories you tell yourself have a direct impact on how long you stick at a task before you give up. If you tell yourself stories that help you see the light at the end of the tunnel, you'll be able to muster more willpower to keep going through adversity. That means you'll be pushing your brain hard enough to trigger neuroplasticity, inspiring the brain to change itself to do better next time. If you tell yourself that it's all utterly pointless and futile, then you'll probably fall by the wayside before you reach your destination, and lose out on developing to your full potential.

Self-belief can make the difference between success and failure according to whether it increases or decreases your motivation to pursue a given goal regularly, intensively and for long enough to trigger brain changes that improve your abilities. Tell yourself the right stories, those that bolster rather than erode your self-confidence, and you will naturally find yourself with the get-up-and-go to willingly and enthusiastically take the steps necessary to get you where you need to go. Sadly, we don't always tell ourselves the right stories.

Priming matters

When Chinese American girls were "primed" to think about the long, proud history of mathematical excellence among people of East Asian origin, they did significantly better in maths tests. But when they were reminded that males usually score higher than females in subjects that rely on a strong mathematical ability, their scores were much worse. The stories we tell ourselves make a big difference!

The beliefs you hold right now were shaped by other people, in the beginning at least. They started forming based on what other people around you believed; beliefs are catching like that. Beliefs about what makes the world go round, what's important in life and what's not, how you should treat other people and how you shouldn't – these became consolidated or not as the years went by, according to whether the stories you repeated to yourself propped up these beliefs, or went against them.

The themes, concepts and ideas that were repeated the most often, as you told yourself these stories day in and day out, eventually became internalised. They got written into the very fabric of your malleable mind, changing how you see the world around you, the other people in it and yourself.

Your self-beliefs formed according to the feedback you received from others, particularly from those you looked up to the most. Along the way some of this feedback will inevitably have been inaccurate, projected onto you by people struggling with their own demons. Accurate or not, your self-beliefs became moulded according to the stories you've been repeating to yourself ever since.

What happened to date is all in the past. Nobody can tell you what you should or shouldn't think from now on. Your own private world inside your head is your own business and you have more choice over what

stories get repeated in the theatre of your mind than you might realise. *You* are the director of the movie that is your life.

If you don't like some of the beliefs you currently hold, because you suspect they hold you back rather than propel you forward, then you can change the stories you tell yourself. You may have got into some bad habits along the way, by allowing your attention to get dragged into whirlpools of negativity on a daily basis, both in the real world and online. But you *can* take control. You can point your attention elsewhere and nurture a more optimistic outlook by repeatedly telling yourself the positive stories that will ultimately change your beliefs for the better – filling your sails with wind, getting you moving in the right direction.

A spectacular sham

A 76-year-old man in the USA had surgery on a dodgy knee that had been giving him grief for the previous five solid years. A couple of years later, his osteoarthritis was gone. It no longer hindered his movement, nor caused him any discomfort. It was nothing short of life-changing. Is this a fine example of modern medicine improving someone's quality of life with a simple keyhole operation? Or perhaps it was some other kind of miracle? This was no standard surgery.

He went to the hospital at the appointed hour and was taken through all the usual steps of presurgical preparation. The risks associated with the procedure were discussed, the damaged knee was marked up to avoid any mix-ups, appropriate anaesthetics were injected and so on. The surgeon made a small incision into the skin of the knee, through which the surgical tools could gain access to damaged tissue, but then he stitched him straight back up and moved onto the next patient.

Neither of the usual procedures common in surgery for osteoarthritis of the knee were carried out. The inflamed cells on the surface of the two leg bones – just behind the kneecap – were *not* snipped away, nor was

the fluid inside the knee flushed out to get rid of any irritants. Yet the patient's knee got much better all the same. What's that all about?

People who hold positive beliefs about ageing actually age more slowly than those who view the process of getting old negatively. The positive thinkers live, on average, 7.5 years longer. A positive mental attitude really does make a difference, to all sorts of health outcomes.

Was the doctor trying to make a fool of the patient? Does this prove that all those years of griping to anyone who would listen about the gammy knee was all in the patient's mind? How else could the discomfort and mobility issues disappear given that the surgeon hadn't actually ventured *inside* the knee?

Firstly, the pain and discomfort were certainly not "all in his mind," because there was plenty of medical data to prove the presence of inflamed tissue inside the joint. So we can rule that out. What really made the pain go away was the patient's *belief* that he was in safe hands and that the surgery had gone smoothly.

As he was fully convinced that the procedure had been a complete success, he told himself stories that resulted in a strong and enduring belief that he would make a full recovery. Knowing that his surgeon was a bit of a superstar certainly wouldn't have hurt. After all, he was the go-to man for any knee injuries sustained by the local NBA team and was often to be seen on the touchline when games were aired on television. The knowledge that his doc was the best in the business could only have boosted his *faith* yet further.

In the absence of any real surgical intervention, the only reasonable explanation for the clear improvements in the knee pain, strength *and*

flexibility is that the patient's brain was the cure. His *mind's* firm belief that the doc's intervention would remedy the ailment was sufficient to trigger the healing that took place in the damaged *matter* inside his knee, a clear-cut case of *mind over matter*.

Optimism bias

Our 76-year-old man with the dodgy knee was no muggins. The doctor simply created a helpful and utterly convincing *illusion* that enabled the patient to tell himself positive stories – about having had the best surgeon, a successful procedure, a good prognosis and so on – and *this* led to a strong belief that his knee would heal. An extremely positive mindset, sustained over many months, is what actually did the healing. But how could a positive expectation possibly trigger the long-lasting easing of his pain and improvement in mobility?

The most likely explanation was that the patient's *optimistic outlook* caused the release of biologically active molecules that actually brought down the inflammation and, at the same time, reduced the amount of stress hormones released into the bloodstream that might otherwise have interfered with the natural healing process. Once the thought-induced reduction of inflammation had a chance to work its magic over the weeks he spent rehabilitating after the knee "surgery," he ended up with significantly improved pain and mobility.

Healing a dodgy knee with some benevolent deception to trigger the power of positive thinking is one of many ways to bring these *mind-over-matter* capabilities to the fore. The "placebo effect" is how this phenomenon is described in the medical literature, so if you thought that was all about being fobbed off with sugar pills, then think again. The placebo effect (Latin for "I will please") describes any situation that enables a patient to really, truly, deeply believe that their illness will improve. And that belief is what enables people to produce more of the helpful biological molecules and fewer of the unhelpful ones.

You may have heard that proper rigorous clinical trials *always* try to compare outcomes of a treatment group against a separate group of patients who are given placebo treatment only. Well, the reason for this is to make sure that the drug or procedure being tested actually results in improvements *above and beyond* the well-known power of belief to improve matters all by itself. This alone is testimony to the power of your brain to exert meaningful biological changes inside your body.

Have you ever had a headache disappear as soon as you swallowed a pain killer? Long before it could possibly have dissolved in your stomach and made its way into the bloodstream? That's the placebo effect right there.

Placebo power

The effectiveness of the placebo effect in harnessing mind over matter is not just limited to reducing pain. It has also proven to be effective in reducing feelings of depression, accelerating recovery from cancer and even improving symptoms of Parkinson's disease.

Parkinson's disease is characterised by difficulties initiating smooth, well-coordinated body movements. When the drugs that treat this condition in its early stages stop being effective, patients are sometimes offered surgery to implant electrodes deep inside their brain. After surgery, the battery-powered implant must later be switched on. At that point the very weak signals generated in the patient's basal ganglia get a bit of an electric boost so that they can produce movements normally. Amazingly, symptoms can improve even under circumstances where the patient *believes* that the implant has been switched on, even though in reality it's still switched off.

Nobody's suggesting that the movement difficulties experienced by Parkinson's patients are a figment of their imagination. Their brain scans would prove this beyond a shadow of a doubt. Instead this is another

example of how a positive expectation makes a tangible difference to important real-life situations.

Can I get a hallelujah?!

A study investigating the power of prayer found that, if a person recovering from illness was convinced that a large number of people were regularly praying for them, it actually accelerated the healing process! Interestingly, it didn't make any difference whether people were really praying for them or not, it was the *belief* that people were sending them positive vibes that made the difference.

Even terminally ill cancer patients have been taught to harness the power of mind over matter to significantly outlive their prognosis. In a few cases, patients given just weeks to live by their oncologists have gone on to achieve full remission.

In this case their powers of mind over matter were brought into play not with a pill, surgery or implant but instead a combination of daily stretching and psychotherapy – to help them actively reduce their stress levels – and art therapy. They drew a series of pictures that helped them to vividly picture a powerful, army of mighty immune cells pulverising the weak, malfunctioning cancer cells that had invaded their body. So rather than feeling overwhelmed with fear that the cancer was rampaging through their body, they could use the images they created to tell themselves stories that gave them the belief that their immune system would conquer it. In combination with the standard cancer therapies, and against all the odds, this is exactly what many of them achieved.

Secrets of happiness

Doing whatever it takes to develop an optimistic outlook can accelerate healing, but the advantages of a positive disposition don't stop there. It

turns out that people who often find themselves feeling positive emotions, for no particular reason, enjoy various cognitive benefits. They tend to have more novel and creative thoughts, to be more inclusive in the social groups they participate in and are more flexible, both in terms of coping with moving goalposts and switching mindsets when the need arises. They also tend to be happier.

Now that last insight might sound like a classic case of "stating the bleeding obvious." Of course people who spontaneously experience more positive emotions are happier; surely happiness is one of the positive emotions that puts them in the high positive emotion group in the first place?! Well, a large body of evidence suggests that the spontaneous occurrence of positive emotions actually *causes* a person's happiness levels to go up. And the best news of all is that the spontaneous occurrence of positive emotions can be made more likely by repeatedly telling yourself stories that help you to see the world through rose-tinted rather than sh!t-tinted glasses.

Developing the ability to generate more spontaneous positive emotions also promises to improve your life satisfaction and your resilience – that is the ability to thrive despite high stress. This is part of the reason why making time to play is such a serious business. It doesn't matter whether you get a couple of friends or neighbours over to play a board game, skim stones across a lake or river or throw a stick for a dog, taking time to play makes it more likely that you'll feel upbeat for no particular reason. And *that* increases your resilience.

This is also why being able to see the funny side of life is so important for well-being. Not only can a witty comment break the tension in stressful scenarios, helping *everybody* see the humour in an otherwise tricky situation, but it also encourages people to view everything from a different perspective. And taking a fresh perspective can be just the ticket if you find yourself needing to jog yourself out of a downward spiral.

Your brain constantly scans the sensory signals coming from inside your body as well as those streaming in from the outside world. "Interoception"

In one famous study, people played a ridiculously simple game involving putting a list of random words in alphabetical order. If the words they were arranging related to ageing (words like grey, wrinkled, stooped, etc.), then when the game was over and they left the room, they walked down the corridor at a significantly slower pace than if the words related to youthfulness (words like fresh, energetic, keen), in which case they moved much more swiftly.

The words, themes and attitudes you are exposed to on any given day can impact how you feel and act, more than you'd ever have believed possible.

describes the perception of bodily sensations of your heartbeat, muscle tension, pressure in your gut, the urge to use the toilet and so on. If your interoceptive senses detect a smile on your face, a spring in your step and a body posture that is standing tall, this actually changes how you feel, improving your mood. And best of all, your powers of interoception have no idea whether you're faking it or not.

All too often we focus only on the impact of our mood on the facial expressions and body language we broadcast to the world around us, but it's actually a two-way street. If you catch sight of your reflection and notice that you're scowling, force a smile. If you realise your body is hunched over, sit up straight, pull back your shoulders and take a few deep breaths. It won't instantly transform you from sadness to joy, but it will definitely nudge you in the right direction.

A willingness to be playful, to look on the bright side of life and the capacity to find things that amuse you in your everyday life might never have featured on a list of "required skills" for any job you've ever applied for, but they are all vital for building resilience, developing a lifestyle that is more satisfying and leading a happier, healthier life overall.

When it comes to the important task of trying to encourage ourselves to spontaneously generate positive emotions, another thing we can all do

to help things along is to find ways to reduce negative influences on our daily existence. Anything in our environment that nudges us towards a bleak outlook is hardly going to increase our chances of feeling chipper for no particular reason, is it? While we often don't have a huge amount of control over the physical environments we spend our time in, we *do* have control over what digital environments we are immersed in. And if you stopped for a moment to think about it, you might realise that you're consuming much more doom and gloom each day than is strictly necessary.

Beware the news

There are always terrible things happening in the world. Physical and sexual assault, fraud and extortion, murder, kidnapping and acts of terror, you name it – the sad truth is that it is *all* occurring somewhere in the world right now. Switch on the news, watch crime dramas, movies and documentaries on current affairs, and you'll soon find yourself convinced that the world is going to the dogs. But it's important to bear in mind the news desk mantra: "If it bleeds, it leads."

If it didn't make your blood boil, it wouldn't be in the news in the first place. Why? Because if people don't get emotional, then they don't come back for more. The newspapers would sit on the shelves gathering dust and the advertising slots in your TV show or favourite websites would go unfilled. The news actively filters out the good, and focuses our attention on whatever is most horrific. This makes many of us feel like we're living on a knife edge of calamity, when in fact the average person lucky enough to be living in the developed world is currently living a safer and more comfortable life than their ancestors ever dared dream of.

Unlike our ancestors, we don't just get explosure to what's happening among the 150 or fewer people in our local communities. Global news agencies ensure that whatever are the nastiest, most shocking and outrageous atrocities afflicting the 7 billion (and counting) people on planet Earth, we'll probably get to hear about all of it.

Nocebo

If "placebo" describes the power of positive thinking to trigger the release of naturally produced, helpful chemicals in the body and brain, "nocebo" describes the opposite effect. *Nocebo* (Latin for "I will harm") captures the power of *negative* thinking to make the outcome *worse*.

If you truly *believe* that something is going to hurt you, then even if it does not contain any harmful substances, the negative belief itself can elevate levels of cholecystokinin (CCK) in the brain, *increasing* the pain.

Perception is everything, so we end up being left with the distinct impression that murder, rape and paedophilia is going on all around us. This heightened sense of danger, to ourselves and our loved ones, changes our expectations so that we start to see the glass as half empty rather than half full. Our top-down filtering mechanisms can become primed by the various horrors witnessed during the previous night's telly binge, so that we're that little bit more likely to perceive the negatives in our immediate environments and less likely to spot the positives.

What's more dangerous to your health: nuclear power or sunbathing?

When we think of nuclear fission our minds often jump to disasters like the USSR reactor meltdown at Chernobyl, or devastating acts of war, like Pearl Harbor and Hiroshima being wiped out by nuclear warheads.

When we think of sunbathing, however, we tend to think about the pleasant sensations of sunshine warming our skin on a summer holiday.

(Continued)

This leads most people to conclude, instinctively, that nuclear power is much more dangerous than sunbathing, while the hard truth is that skin cancer from sun exposure kills considerably more people every year than nuclear energy.

Beautiful, wonderful, heroic and heart-warming events happen every day, but they're simply not as visible as the nasty, gory, frightening stuff. Happy stories don't sell newspapers, they don't bring eyeballs to news websites and TV shows, and so they're usually overlooked in favour of whatever has shock value. While you might not have the power to influence what ends up in the news, you *do* have control over how much news you consume and to which sources you go to get the news you *do* consume.

If the information you habitually consume is giving you a bleak outlook on life, making you feel low and giving you the distinct impression that everything is hopeless, then eliminate it. If the source of the information in question is the news, stop watching the news, stop reading that newspaper. If it's doom scrolling on social media that's making you miserable, delete the app from your phone. At least unfollow all the sarcastic, frustrated, angry people who fill your days with bile and find others who post more uplifting stories and pictures. If it's spending time with someone who constantly moans about how terrible everything is, try to limit your exposure to that person.

If you can reduce all these sources of negative "priming" in your life in favour of more optimistic influences, your chances of spontaneously generating positive emotions will be greatly improved. And the more you can nudge yourself in that direction, the happier, healthier and more productive you will become.

Mind-wandering: vice or virtue?

Have you ever noticed that whenever you take a break, your mind doesn't just stop and do nothing, but instead goes on walkabouts? All sorts of

mundane thoughts, and a handful of bizarre ones, zigzag through your mind while you twiddle your thumbs and gaze into space. It turns out that the average person spends 25 to 50% of their waking day in this state. Is this a tremendous waste of time? Proof that our brains are built to procrastinate? Or testimony to the joys of getting lost in thought and letting our imaginations roam free?

Mind-wandering can bring about both negative and positive outcomes, according to whether the emotional content of your daydreams tends to be positive or negative. That's because negative emotions tend to narrow our attention to focus on dealing with immediate threats or dangers, while positive emotions tend to open our attention up to broader possibilities, which helps us to spot opportunities.

Throughout my career as a research scientist I came face-to-face with mind-wandering on a regular basis and didn't even know it. My experiments involved sticking people in an MRI scanner and exposing them to visual stimuli (videos or animations), auditory stimuli (various sounds) or both at the same time.

Each scan took nearly an hour, so I had to give my volunteers plenty of rest breaks while they were still being scanned. When I analysed the data I expected the visual parts of the brain to be active when they were looking at images, the auditory parts to be active when they were listening to sounds, and for the whole brain to go quiet when they were resting.

While the first two predictions, unsurprisingly, were bang on the money, my third assumption was totally wrong. Whenever they were "resting" I would invariably see the inward facing surfaces (particularly the rACC and PCC stops of the Cingulate Cortex; see Inward-Facing Brain Tube Map in the Appendix) light up like a Christmas tree. It seemed a bit odd at the time, but because I was completely focused on how brains perceive the outside world, I totally missed out on the possibility that I was looking at mind-wandering in action! Luckily others figured it out a few years later.

– Jack

Allowing your mind to engage in flights of fancy, to think of playful or silly things that make you smile, to wonder about ways you might go about fulfilling your hopes and dreams can be really useful. This type of mind-wandering is fallow ground for creative thinking and goal setting, to name but two benefits.

If, on the other hand, your mind has a distinct tendency to meander into dark alleyways of self-doubt and unsettling labyrinths of worry, mind-wandering can also be distinctly *un*helpful. If you're the type of person that tends to brood at length about all the terrible things that might happen in the future, or ruminate endlessly about upsetting things that happened to you in the past, then your mind-wandering might be doing you a disservice.

"The mind is its own place, and in itself it can make a heaven of hell, a hell of heaven."
John Milton

We all need to keep a keen eye on the content of our daily excursions into the world of daydreams, taking steps to nudge ourselves back towards a more positive mindset if we start spending too long in the darker recesses of our imagination.

Attention!

Involuntary attention describes how your concentration can get yanked away from the task at hand, either by mind-wandering or when an unexpected disturbance occurs in the outside world. A loud bang from the dustbin men crashing around on the street or a sudden movement in the background that catches your eye will instantly activate the lower part of the PreFrontal Cortex (vlPFC stop) and TemperoParietal Junction (TPJ stop), both on the outward-facing surface of the brain, to break your concentration. These areas act like a circuit breaker – dragging your attention to the unexpected sight or sound – so that you can make sure it doesn't pose a danger. That's *involuntary* or *reflexive* attention in action. It is automatic and beyond your control.

When you then try to refocus on whatever you were doing, the brain areas of *voluntary* attention spring into action, including higher parts of the Frontal District (FEF stop) and Parietal District (IPS and SPL stops), which are also on the outward-facing surface of the brain. These regions *are* under your control, enabling you to point the "spotlight" of your attention wherever you need it. It does this by *filtering out* all the information streaming in through your senses *apart* from what is relevant to you right now.

The brain areas of voluntary and involuntary attention are constantly doing battle with each other. As they vie for dominance you can find yourself able to focus on what you're doing, being distracted by events in the outside world, or drifting off on mind-wandering journeys into the past or future. Fortunately, the more you exert your willpower in gently bringing your attention back to whatever it is you are trying to concentrate on, the stronger your voluntary attention circuits become. As always, practice makes perfect. But you can certainly make your life easier by eliminating as many outside distractions as possible. When it comes to dealing with internal distractions – those unhelpful thoughts that break your focus – well, there's something you can do about that too.

Mind management

When people first try their hand at the types of mindfulness meditation that involve sitting quietly and trying to focus on their breath or different parts of their body (e.g. doing the "body scan" meditation), their minds usually wander off almost immediately. If you think about it, that's pretty ironic.

There they are, hoping to de-stress themselves with a scientifically proven method of improving their physical and mental health, only to find themselves getting incredibly wound up about not being able to pay attention for longer than two seconds at a time! Some people find this a bit frustrating, but soldier on regardless. Many find themselves getting so irritated that they throw their toys out of the pram and vow never to do it again; telling themselves, "It's just not for me." "I'll leave all that nonsense to the New Age hippies!"

Why breath?

The useful thing about breathing and the reason it's an effective way to focus your mind on the present moment, is that it's always changing. Breathing in follows breathing out. Breathing out follows breathing in. Because we have to keep this up our whole lives from birth until death, breathing is a convenient aspect of our everyday lives that we can either ignore and take for granted, or choose to point our attention towards if we want to bring our mind to the present moment. The longer we can keep our mind focused on the present moment, as opposed to the past or the future, the longer we can hit the pause button on life's stresses. It's simple as that.

If you ever find yourself in this predicament, please remember that from your brain's perspective, it's a brilliant workout. Every single time you notice that your mind has wandered and you bring your attention back to your breath again, even if it only lingers there for a few short seconds, you are flexing the network of brain wires involved in "voluntary" attention.

Daily practice of any form of mindfulness meditation will strengthen these neural circuits of "voluntary" attention so that they can begin to dominate over the brain networks of "involuntary" attention. The latest evidence suggests that improvements in self-control of attention are noticeable after just five 30-minute sessions.

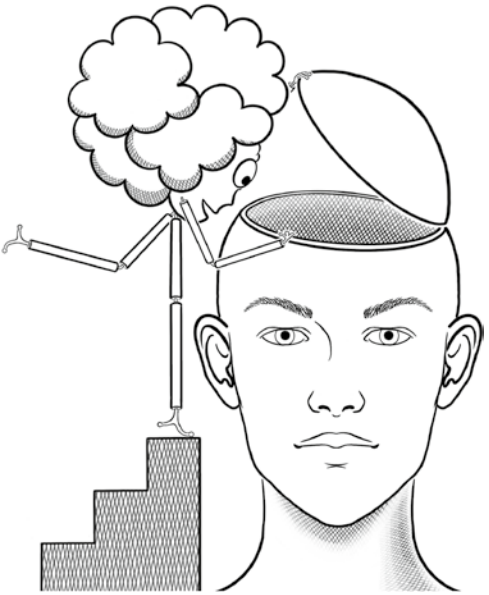
The more regularly you get around to doing your daily meditation practice, the stronger your voluntary attention brain networks become. Slowly but surely your brain's ability to focus lasts longer and longer, enabling not just more effective meditation, but improving your ability to concentrate on whatever it is you need to be getting on with at work, at home or at play.

It makes you better able to block out any distractions going on in the background and so it can help to increase productivity. If you manage to get into a daily habit of doing mindfulness meditation, this is just one

of several aspects of improved cognitive performance that you can look forward to.

Helicopter ride

Meta-awareness is an important cognitive skill that gradually improves with practice. It might sound a bit flash, but really it's just a fancy name for taking a helicopter view on whatever's going on in your head. You observe, without making any judgements on whether they are good or bad, any sensations you can detect inside and outside of your body, how you're feeling, the thoughts that are passing through your mind and so on. It is a mindset where you become aware of what you are and aren't aware of, which helps you improve your ability to take an objective perspective on *everything*. And that's incredibly helpful for giving yourself peace of mind.



Improving skills of meta-awareness by practising mediation on a daily basis will help you to develop a more objective perspective on all of

life's twists and turns. One key advantage of this is that you will naturally start to take things less personally. And you will feel less social pain when other people behave badly towards you. It probably won't change how others behave towards you, but it can change how much you suffer as a result of their unpleasant behaviour.

Getting better at meta-awareness also helps you to catch yourself when your mind-wandering veers into dark avenues where you've started falling in the trap of repeating to yourself unhelpful self-defeating stories that might be eroding your self-belief. It also helps you to get in the habit of regularly taking a fresh perspective on whatever is troubling you.

Considering the relief people feel after gaining a fresh perspective from talking their troubles, hopes and fears through with trusted friends, colleagues and family members, the added value of using meditation to achieve the same goals should already be clear. And considering that the main benefit of psychedelic psychotherapy for severely depressed people is the complete change of perspective it gives them, you might like the idea of getting similar benefits without having to go anywhere near powerful psychoactive drugs. There are many ways to shift perspectives to reduce suffering and the great thing about meditation is that it's the most readily available option of them all.

When you regularly engage in meta-awareness through meditation, your posterior cingulate cortex (PCC stop) is the key part of the brain network that helps you take on this objective mindset. It only takes just 10 to 20 sessions of 30-minute daily meditation for the white matter connections that feed information in and out of the PCC stop to become stronger. Strengthening the PCC white matter results in improvements in mood, and thus the closer you will come to the goal of spontaneously generating positive emotions more often.

Clock up a few more sessions of daily mindfulness meditation and, after about a month, enough new synapses will have formed to measurably increase the amount of *grey* matter in the PCC stop – proof that daily meditation physically changes your brain in a way that improves your mood management.

Optimal prime

If, on any given day, you start feeling like there's a rain cloud following you around wherever you go, use this as a cue to remind you to consider the steps you can take to change your thinking patterns:

1. Switch off or reduce exposure to the sources of negative stories in your daily life.

2. Remember to prime yourself with positive thoughts.

3. Make sure you're providing your brain with its basic needs. Get outside in the sunshine, play a game, take some exercise, hang out with friends, eat the fresh foods that your brain uses as building blocks and get the rest you need.

Picture it positively

When you wake up in the morning, rather than thinking, "Oh no, today's going to be a nightmare," try to prime yourself more positively along the lines of "Today is going to be a great day. It's showtime!"

When you notice that it's past midday, give yourself another positive prime: "I might not perfect but I'm pretty damn good. Let's get cracking!" – or whatever positive self-talk you can tolerate without cringing.

Then at the end of the day, when your head hits the pillow, prime yourself for a good night's sleep with something along the lines of "Tonight I'm going to sleep like a baby and tomorrow is a brand-new day."

It might sound cheesy, and no doubt you can find words that suit your own personal taste better, but if you do this it WILL make a difference.

Just by being proactive in taking control over the things you *do* have influence over, rather than fretting over the things you have no control over, can be enough to encourage a more positive outlook that leads to more spontaneous positive emotions throughout the day. And that, as you now know, is what leads to happiness.

Far Eastern traditions may have been the first to discover the calming, healing and brain-enhancing powers of mindfulness meditation, and New Age hippies travelling around the Orient may have been among the first to bring it back to the Western world, but by now it really is an everyday phenomenon. It is scientifically proven to improve your physical health, your psychological well-being and even boosts your cognitive performance as well. It's available to all, wherever you are, whenever you need it. And best of all, once you've learned the basics, it's completely free.

Chapter takeaways

- Nurturing a positive mental attitude improves how the brain and immune systems function; it's also proven to reduce stress.
- Don't waste time and energy worrying about things that are not under your control. Focus instead on what *is* under your control, starting with reducing your exposure to all the terrible things happening in the world and increasing your access to more positive influences.
- Positively prime your brain three times a day: when you wake up, at midday and when your head hits the pillow last thing at night.
- Meditation changes the fabric of your brain, improving your ability to focus your attention, gain perspective and better regulate your mood – it's not just for hippies!

Hold onto Your Marbles

Over the hill

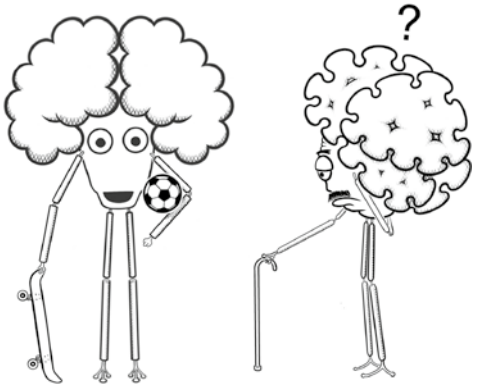
As far as the *structure* of your grey matter is concerned, once you're past your mid-20s, it's downhill all the way. Your brain actually begins to shrink. But that doesn't mean that brain *function* peaks in the mid-20s. Several cognitive abilities actually become more efficient as you age, despite the very gradual structural degradation. In this regard, a better system of wiring is more important than having more wires.

> Every day of your adult life your cortex loses 85,000 neurons – that's one every second!

Throughout middle age and beyond, the branching antennae (dendrites) that pick up signals from other neuronal brain wires progressively retract and lose the spiny tendrils that are studded with synaptic connections. The exceptions to this rule are the neural pathways involved in mental activities that you regularly challenge your brain to tackle. This helps to ensure that the relevant synapses are maintained to keep those particular neural pathways buzzing along nicely.

Unfortunately, whatever you do, the myelin wrapper around the brain wires that speed up the electrical transmissions will gradually lose its integrity. This part of the process usually kicks in during your 40s, accounting for the slower reaction times among the middle-aged versus younger folks.

These processes all lead to a thinning of your cortex – the outer layer of your brain within which billions of wires share their electrical information across your ever-diminishing numbers of synaptic connections. As a consequence of all this brain shrinkage, the valleys at the surface of your brain get wider, the peaks get narrower and, deep inside the brain, the fluid-filled spaces (aka ventricles) become larger. And, as if to add insult to injury, your neurotransmitter receptors that receive the chemical messages released from the opposite side of the synapse, causing an effect inside the next neuron in the chain, become ever so slightly less efficient as each month goes by.



This gradual decline is an inevitable and inescapable fact of life. If we all lived to be 150 years old, we'd all end up displaying signs of age-related cognitive decline (ARCD) eventually, as a result of all these natural processes of brain ageing. Being around for that long would mean that, at some point, we would all have succumbed to the forgetfulness, the tendency to be easily distracted and the somewhat compromised problem-solving abilities that characterizes ARCD.

Sadly for many people, ARCD kicks in far too early on in life. While some people still function just fine well into their 90s, only starting to show obvious signs of decline as they approach the century, for others it can begin to interfere in the tasks of daily life much sooner – perhaps even in their 40s or 50s. We've all encountered it at some point, whether it

is someone who constantly forgets that they've already told us their favourite stories many times before, a person getting confused about how to navigate a route they have taken countless times or a relative who consistently calls their loved ones by the wrong name.

Witnessing cognitive decline in someone else can be one of life's most harrowing trials, but for the person actually experiencing it, it's something else altogether. The transition from strength and vigour to weakness and frailty is tough enough to deal with, but lacking the capacity to care for your own needs, not to mention the loss of dignity associated with losing your independence, can be truly devastating.

ARCD may be an inevitable thing in the long run but, you'll be pleased to hear that there *is* some good news. The speed at which these processes unfold varies greatly from one person to the next. In many cases, inherited genetic conditions notwithstanding, it seems that these differences are largely to do with factors over which you can have significant control. Rather than abandoning yourself to fate, you can instead establish what you can do to hold onto your marbles for as long as possible – and then do something about it.

The really great news is that many of the things you should be doing to ensure you maintain a healthy brain for as long as possible are enjoyable activities – activities that get you out and about, that involve interacting with other people and generally having a good time.

Putting the brakes on

Thanks to incredible advances in medicine, life expectancy continues to lengthen. It's great to know that we're all likely to be around for considerably longer than the vast majority of our ancestors. By the standards of the average caveman or cavewoman, anyone surviving into their 40s would have been considered incredibly old back in the Stone Age! Now that we usually live for much longer, our chances of having to live with ARCD are also much higher. This leads to the billion-dollar question: what

can we do to stay sharp for as long as possible, ideally right up until the day we do finally conk out?

Well, there are several things that we can all start doing right now. Many of them are simple things that we've already covered in this book that, unless you've skipped straight to this chapter, you already know about. Out of all the practical bits of advice, there are two highly effective brakes that you should seriously consider applying sooner rather than later, if you haven't already done so, to slow your descent into ARCD.

1. Reduce free radicals

Without drilling down into too much detail, a free radical is to the structure and fabric of your brain "like a bull in a china shop." If not brought under control, the bull will eventually smash the shop to smithereens. As with all classic tales, the story of free radicals involves a lifelong struggle between good and evil.

The goodies are the antioxidant foods that, when regularly introduced into the battleground of your body and brain, willingly give up a spare electron to any free radicals that happen to be knocking around. This renders them harmless before they can do any damage. In the absence of any nearby antioxidants, the desired electron will end up being snatched indiscriminately from a nearby piece of cellular machinery, introducing faults and malfunctions that gradually accumulate over a lifetime to interfere with normal brain function. The heroes in this particular saga are the fresh fruit, vegetables, coffee and teas that provide a plentiful supply of brain tissue-protecting antioxidants whenever they are ingested in sufficient quantities on a *daily* basis.

The baddies are the toxic substances that are routinely taken into our bodies through our lungs, guts and skin, sources of an overload of free radicals, on top of the ones our bodies and brains naturally kick out in the first place. The villains in question include fatty foods, exhaust fumes and cigarette smoke.

2. Keep your blood pipes clear

The best three possible things you can do to keep your blood pipes clear are to stay away from smoking, keep your intake of saturated and trans fats to a minimum and take exercise – the moderate to intensive type of exercise that gets you out of breath – *at least* every other day.

As you know, the typical Western diet is abundant with saturated fats. Without wanting this to start sounding like some kind of conspiracy theory, adding saturated fats to processed foods really does help big multinational companies to boost their profits, so they do it with wild abandon. Cutting down on saturated fats means not just reducing or eliminating red meats, but also avoiding processed foods – like pies, cakes and biscuits – wherever possible.

Make time to prepare fresh food, rather than the processed ready meals. Choose chicken over pig products and turkey over beef. It doesn't mean that you should never again eat the foods you love. Just eat the stuff high in saturated fat as a weekly treat rather than a daily habit. Or to put it the other way round, it's all about eating the lean healthy stuff daily and the delicious fatty stuff infrequently. The best news is – and this is entirely true no matter how unlikely it sounds – the less often you eat the naughty stuff, the better it will taste!

Animal fats and the tars in cigarette smoke clog up your arteries – the blood vessels that must constantly supply oxygen and glucose to every single cell in the body and brain, every moment of every day, or risk cell death. This process (known as atherosclerosis) causes sticky plaques to accumulate along the insides of your arteries, gradually clogging them up and making the job of forcing blood through those tiny, narrow tubes much harder – increasing blood pressure as a result. But that's not all. Not only do atherosclerotic plaques make these vital blood pipes narrower, but it also makes them more rigid too.

Usually, as each heartbeat forces more blood into your arteries, they stretch and bulge out before the elasticated walls snap back into place (you can feel this when you take your pulse) to squeeze the blood

onwards before the next surge of pressure is produced by your beating heart. Atherosclerosis makes arteries lose their elasticity, making the narrowed blood vessels even more inefficient in piping that much needed blood around the body and brain.

The reduction in the amount of blood that can be carried at any given time due to narrowing of vessels, along with the loss of elasticity, is negligible from one day to the next. Yet the incremental reduction in effective transport of that precious oxygen payload gradually takes its toll over many years. You are unlikely to notice the impact from year to year, but from decade to decade its effects can become deadly. If the supply of oxygen-rich blood to one of the major muscles of the heart is completely cut off, even if it's just for a few minutes, that part of your heart muscle will stop working and soon begin to die off completely – never to function properly again.

The first sign of trouble usually comes after many years of gradual changes in the blood vessels supplying your heart with everything it needs to do the energy-consuming job of keeping its muscular chambers permanently pumping. By the time someone has a heart attack, many of their heart's blood vessels will have narrowed to three-quarters, possibly a half and sometimes even a quarter of their original width due to all the atherosclerotic plaques that have accumulated.

Although heart attacks are triggered when the blood supply to part of the muscle tissue is completely cut off, the heart can also be gradually weakening and losing its natural rhythms in the years leading up to the cardiac arrest. During these years, the weakening heart is less efficient in delivering on its crucial role of keeping every corner of your brain supplied with oxygenated blood 24/7.

Brain attack

Although heart attacks are pretty common and fairly well understood, most people seem to be unaware that the same process can also take place in the brain. This is why a high dietary intake of saturated fats is

associated not only with a high incidence of heart failure but also with a high incidence of stroke. If a heart attack is the name for the situation involving the blood supply to a certain chunk of heart tissue being cut off to stop that tissue functioning properly, then a stroke might be better described as a "brain attack," because it is exactly the same problem but affecting the blood supply to a different organ.

A body of evidence is accumulating to suggest that the symptoms of cognitive decline are often caused by a series of tiny undetected strokes that occur throughout life. "Silent cerebral infarcts," as these mini-strokes are known, may also play a role in causing migraines when they damage the white matter that ferries electrical information from one brain area to another. Our only hope of protecting ourselves against all this is to do what we can to ensure healthy blood flow.

A most misleading word

When used in its medical context there could not possibly be a more misleading word than "stroke." It conjures up images of something that is gentle, soft, mild and perhaps even soothing. The reality for those afflicted by strokes is quite the opposite.

If the blood supply has been cut off to stops along the Motor Line, then certain muscles of the body will become paralysed. If the blood supply has been cut off to stops along the Visual Line then, despite having perfectly good eyes, vision will be damaged. And if the interruption to blood flow robs the far end of the Reward Line of its precious oxygen and glucose, then the person will find themselves flummoxed by even the simplest of choices. Soothing, mild, soft and gentle – strokes are most definitely *not*!

If the threat of a heart attack doesn't inspire you to give that double sausage, double egg, chips and fried bread breakfast feast a miss, then maybe the equally likely threat of a brain attack will make you think twice.

Again, it doesn't mean you need to completely cut out eating your favourite fry-up forever. If you can, simply try to make a habit of eating fresh foods low in saturated and trans fats on a daily basis, with the occasional celebratory gastronomic blowout from time to time.

Brain-bolstering activities

Avoiding saturated fats and toxic smoke to keep the blood vessels wide open and flexible is only half the story. Eating healthy food (fruits, vegetables, fish, nuts, seeds, spices, pulses, lentils and wholegrain cereals) on a daily basis ensures that your blood is filled with nutrients. If the very pump that distributes this nutrient-rich broth to every cell in your body is strong thanks to regular exercise, then it will reach every nook and cranny of your brain. Your brain is constantly in need of raw nutrient materials to build new connections, recycle neurotransmitters and make new ones from scratch, carry out maintenance on its thousands of miles worth of brain wires and keep the myelin go-faster wrappers on those wires in a good state of repair.

If your heart is allowed to fall into disrepair by, for example, always choosing to drive instead of walking, or never getting round to spending around half an hour every other day out of breath, then it will become weaker. So when it comes to keeping every part of body and brain fully stocked with all their basic requirements, it will fall short and will fail to deliver. It's as simple as that.

It's never too late, but the older you get, the more vigilant you need to be in terms of eating healthily and exercising regularly. Decades of self-abuse can be turned around and, indeed, the weaker your heart has become, the greater the benefits you will perceive once you start making the lifestyle changes necessary to strengthen it. You'll have more energy and you'll feel more motivated. Hopefully you'll use this added get-up-and-go to do things that are active, sociable and mentally stimulating. Once you're out there doing these kinds of things on a regular basis

you'll find that your mood, on average, improves and so you'll naturally feel inspired to do more of these things and be more open to trying out new activities that might make you feel even better still.

Cog-turning activities

Go bilingual. It's not just knowing how to speak two languages, but regularly *using* them that boosts brain power in a way that resists the cognition-withering processes of ARCD. It's been discovered that, compared to purely monolingual brains, bilingual brains have better capabilities for task-switching and sustained attention that hold you in good stead well into old age. These days you can sign up to a free website that pairs you up with retired native speakers in their home country, so that you can practise your second-language skills and they can get a bit of company over free videoconferencing services on a weekly basis. Win-win!

Table tennis. Not only does it get your heart pumping, but it's also great for keeping your grey matter trim. Your brain is fully engaged when your hand-eye coordination, reaction times, spatial awareness and need to dream up new tactics to defeat your latest foe are all pushed to the limit. If you have access to virtual reality you can now play people from all over the world, without even having to leave your home.

Juggling. Juggling helps to rapidly induce measurable neuroplasticity. With the need to carefully monitor, quickly react to and guide movements towards fast-moving objects in your peripheral vision, it really puts your IntraParietal Sulcus (IPS stop) through its paces and pushes your Visual Lines to new levels – an all-round, top cog-turning activity. Once it becomes too easy, you can "up the ante" and give your Cerebellum light railway network an even bigger balance and coordination challenge by doing it standing on one leg.

This newfound drive to take part in a range of different activities will, if done regularly enough, stimulate reinforcement of the connections between all the different brain areas involved in carrying out those activities. And, if they are sufficiently stimulating, they will even help you build something called "cognitive reserve," which keeps dementia at bay for longer. Physical activity is the key to a healthy heart – which is, quite literally, the driving force behind mentally stimulating, sociable activities that challenge your brain to change.

Building cognitive reserve

The Einstein Aging Study (so named because it was conducted by the Albert Einstein College of Medicine; Albert himself was not involved) followed 2,000 people aged 70 and above who were residents of the borough of the Bronx in New York City. Each year, initially for four years but ultimately for several decades, they were put through a variety of tests to monitor changes in their physical strength, balance and coordination, along with various cognitive abilities.

The aim was to examine the impact of specific lifestyle choices on the various factors that influence a person's ability to look after themselves, with ARCD high on the list of priorities. Specifically, they were interested to know if there were any particular hobbies, games or social activities that might somehow help to condition the brain to resist the cognitive impact of the metabolic inefficiencies that inevitably crop up as we age.

Eh? Speak up!

When people start losing their hearing they are often reluctant to get a hearing aid. While it's understandable that they are not keen to start wearing something so readily associated with getting old, from the perspective of brain health this is a terrible idea. Even mild hearing loss accelerates ARCD!

The problem is that if you can't hear what people are saying, then you can't participate properly without constantly interrupting to ask people to repeat themselves. As this becomes irritating for everyone, people often start pretending they've heard when they haven't.

Not being able to fully participate in conversation means several things: 1) Brain networks involved in interpreting what people are saying and others that help you form your own sentences stop being reinforced (use it or lose it). 2) It becomes harder to stay up to date on what's going on around you. 3) You start to feel socially isolated. Hearing aids are tiny these days and some are even disguised as headphone ear buds. No excuses now – just do it!

The Einstein Aging Study found that four activities in particular were associated with a significantly reduced likelihood of developing symptoms of cognitive decline. These were regularly playing a musical instrument, playing chess or card games like bridge, reading books and any type of dance that requires a dance partner. These all seemed to have a positive impact on the ageing brain in terms of slowing the rate of cognitive decline.

They also found that those who had an active social life, who regularly took moderate to intensive exercise and participated in the above activities at least once a week enjoyed a longer period of dementia-free life. Given that brains physically change to better accommodate *any* specific behaviour that is practised intensely, regularly and consistently, it will come as no surprise that occasional engagement now and then with the above activities does little to keep dementia at bay.

All of the above activities are mentally taxing – a key defining feature of activities that actually inspire the brain to make beneficial changes. If you don't up your game in terms of tackling more and more challenging versions of the same activity, then the brain loses its incentive to make

changes that lead to further improvements. Let's take a closer look at each of the activities to try and better understand why they might help to future-proof the ageing brain.

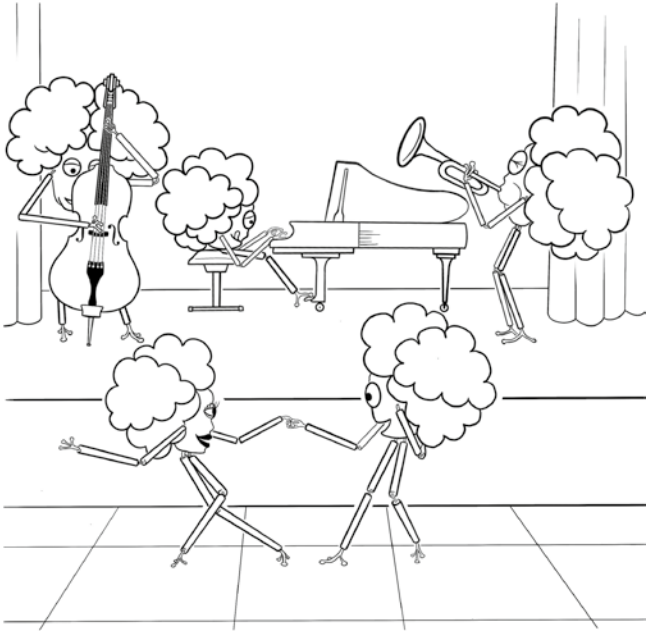
Playing a musical instrument involves manipulating an object with various parts of the body (e.g. fingers, lungs, lips and tongue for wind instruments) to produce tightly coordinated movements. These movements must translate into the production of sequences of sounds delivered with the appropriate pitch, duration and style, all while keenly listening to *all* the sounds that are being produced, not just by yourself, but also those made by others in the group, to ensure that the desired overall effect is being created. Recent brain imaging research has even demonstrated that when people play music together their brain activities become synchronised!

Each of these processes is pretty demanding in its own right. While putting them all together at the same time may seem, from the outside, as effortless as a swan gliding serenely across a lake, it really involves some furious peddling beneath the surface that tots up to a fantastic brain-sharpening work out.

Chess requires potential moves of both players to be imagined and held in mind so that further possible future moves can be mulled over and compared to each other. Opportunities and pitfalls of each potential sequence of moves must be analysed to select the best strategy. The more moves in advance a person tries to plan, the harder the brain areas that support working memory (the Hold Line) are pushed, to try to keep in mind where all the pieces would stand after each imagined move.

The harder working memory is put to the test during the day, the more work will be done overnight to reinforce the synapses connecting the stops within the Frontal and Parietal Districts to increase their capacity for next time. And as you know, improving working memory can boost IQ scores by providing a sturdier foundation from which many other aspects of cognition benefit.

Dancing with a partner is a quintessentially social event. You'll recall that regular social contact with other people has a powerful positive impact on health and well-being in any context, but it's even better if you're meeting up to dance. Many different types of dance bring two people into direct physical contact, which means a good dose of oxytocin gets released from both parties' pituitary glands to induce those stress-relieving feelings of trust, comfort and belonging.



On top of that the cognitive challenge of dancing rivals even that of playing a musical instrument in a band. Your Auditory Line has to produce the sound of the music that you hear from the air vibrations that reach your ears and the Basal Ganglia stop has to lock to the beat so that your movements can be synchronised to the rhythm. Your Visual Line has to create your perception of what your instructor is demonstrating, passed swiftly onto the Hold Line so that you can keep what you're supposed to do in mind until the time comes to reproduce those movements yourself.

The Mirror stop converts the body movements you've observed into signals enabling you to mimic them with your own body. The Motor Line has to initiate movements in time with the music, in various parts of the body. And your Cerebellum light railway has to constantly fine-tune the signals sent to your muscles so that you don't fall over!

Of course none of this happens in isolation. To make it an even greater challenge for your brain, you have to coordinate all of this with your dance partner's movements, keeping you light on your feet and agile of mind. You'd be hard pushed to find a better whole brain workout!

Reading involves converting strings of letters into words, words into sentences and keeping the meaning of one sentence in mind in light of those preceding and following it. According to what you read, images are sketched out in your mind's eye, sounds in the mind's ear, tastes and smells in the mind's mouth and nose. Previous chapters of whatever book you happen to be reading must be brought back to mind in order to interpret new events and imagine future scenarios in anticipation of the most likely outcomes. The trajectory of the plot must be tracked while a dynamic impression of the characters' personalities is assembled, not to mention the often complex and shifting interrelationships between them and knowledge of what they do and do not know during the intertwining narratives. Fabulous mental gymnastics are performed any time we lose ourselves in a good novel.

Nuns on the run

In 1986, the USA's National Institute on Aging funded a study in which 678 Roman Catholic nuns were tracked over many years in an effort to better understand Alzheimer's disease. They were tested on a variety of cognitive abilities, including holding a list of words in memory, how many animals they could name in 60 seconds and their ability to count coins.

The idea of studying nuns was inspired by the fact that their life experiences tend to be very similar. Any differences in the onset of age-related psychiatric problems could then be more accurately attributed to nature (their genes) as opposed to nurture (their life experiences). And the nuns had all agreed to donate their brains to science when they died, so that they could be examined for tell-tale signs of Alzheimer's disease.

Unsurprisingly the brains of many of the sisters who had developed symptoms of Alzheimer's in life exhibited a large accumulation of beta-amyloid plaques and neurofibrillary tangles after death, both of which are broadly accepted to be typical hallmarks of this particular disease. Amazingly, some of the nuns had extensive beta-amyloid and neurofibrillary damage to their brains, yet had *never* exhibited symptoms of Alzheimer's throughout their lives. How could this be?

This proved that some people can still function normally, even with significant physical damage to the brain. The question on everybody's lips was: what made them different? Curiously, analysis of what differentiated those who did and did not have symptoms, despite similar levels of physical damage, indicated that their writing style (taken from essays they wrote way back when they first became nuns in their 20s) seemed to make a big difference.

Nuns whose sentences were packed with many different concepts, as opposed to very simple prose, were significantly less likely to develop symptoms of Alzheimer's several decades later! Beyond that, another key factor was their mental and physical activity level before and after their daily duties. Those who read avidly and pursued hobbies with great zest in their spare time were still functioning extremely well right into their 90s, while those who kept themselves less mentally active in their free time tended ultimately to succumb to the ravages of dementia.

Alzheimer's disease versus Alzheimer's dementia

By the time people with Alzheimer's disease-related dementia develop the symptoms of chronic forgetfulness and problems with planning and execution of simple day-to-day chores, their brains have invariably accumulated a significant degree of damage. The beta-amyloid plaques and neurofibrillary tangles that appear as dark patches in brain scans were for a long time thought to be what caused the affected brain cells to die off. The latest thinking is that rather than being the cause of the trouble, it may in fact herald a doomed attempt to salvage the dying brain cells. Either way, as far as we currently know, their presence signifies irreversible death of brain cells.

This irreversible decline often starts in the hippocampus (DG and EC stops) and PFC areas vital for the various mental operations that together fall under the banner of "executive functions" (i.e. planning, sustained attention, decision-making and the like). The great news here is that people seem to be able to live a perfectly good and healthy life even when the currently unstoppable rampage of Alzheimer's damage progresses through the brain, so long as they have built up sufficient cognitive reserve by regularly keeping their brain challenged.

What exactly is cognitive reserve?

Two individuals can have exactly the same degree of beta-amyloid and neurofibrillary tangle damage, but one experiences a negligible impact on daily activities while the other is dependent on family or carers to get through the day.

It all seems to boil down to what has become known as cognitive reserve. What sets them apart is, almost always, their level of education and lifestyle choices. Better-educated people are more likely to adopt healthy diets, relatively high levels of physical activity and lifestyles that are mentally stimulating. This in turn is likely to result from positive childhood

associations between physical exercise and mental stimulation that have fostered long-lasting habits maintained throughout adulthood.

This doesn't mean, of course, that less well-educated people can't do this too. All they need is the motivation to get stuck into these cognitively demanding activities on a regular basis. Anyone can spend time reading, dancing, learning a musical instrument or new language and play mentally stimulating games.

People whose childhoods were not so idyllic should take strength from the fact that it is never too late to develop new habits. All it takes is daily adherence to sustained, fairly intense physical and mental exercise over several weeks and eventually new habits will form that perpetuate these behaviours. It just needs to become part of your daily routine.

To recap, by consistently challenging your brain it is continuously compelled to put the work in each night to create new synapses in the pathways involved in whatever brain function you've been exercising. This makes subsequent execution of that and any related behaviours work a little bit better next time, so that they can be executed slightly faster, more accurately and with less effort.

The key point here is that after many years of strengthening the interconnectedness of those brain networks in this way, especially those in the PFC, you end up with an awful lot of redundancy. When it comes to brains, that's a good thing. Redundancy in the brain has nothing whatsoever to losing your job and everything to do with being able to get by with bits of your brain not pulling their weight properly due to temporary or permanent damage.

Redundancy in the brain

Now you know that the key to keeping ARCD at bay is building cognitive reserve. The increased connectivity between stops in the Frontal District involved in orchestrating attention, planning and problem-solving

enable various mental operations to be achieved in different ways. These densely interconnected brain areas can then reorganize to take over functions lost when certain brain areas are permanently compromised through the cellular changes of Alzheimer's disease, mini-strokes or head injury, for that matter. This also accounts for why the more physically and mentally active elderly individuals seem to be able to hold onto their marbles for longer.

The Columbo effect

One rather odd factor that seems to be positively correlated with delayed onset of dementia is good dental health. It may sound strange, but the better you look after your teeth, the better the chances of keeping cognitive decline at bay for longer.

It might simply be that the close proximity between brain and mouth leaves brain tissues vulnerable to disease-causing agents that gain entry via damaged teeth and gums. It may also have more to do with the immune system in general than anything specifically to do with your gnashers, as elderly people who undergo major surgery or suffer a succession of minor illnesses are more likely to experience accelerated cognitive decline than those who don't. Anything that excessively mobilizes the immune system, to aid recovery from surgery or a medley of minor bugs, may accelerate the processes of ARCD.

What put researchers onto this possibility was the fate of the wonderfully talented Peter Falk, who famously played the shabby, loveable detective Lieutenant Columbo. At the start of 2007 he was already suffering from mild cognitive impairment, but was still mentally sharp enough to be hard at work shooting a film called *American Cowslip*. Sadly, his cognitive abilities went into a tailspin after a series of major dental surgeries.

On a related note, many middle-aged and elderly people suffer from rheumatoid arthritis. This is an "autoimmune" condition where the immune system attacks the joints, leading to painful swelling. Eventually this can progress to irreversible stiffness of the affected joints. For a long time there was no cure or preventative agent that might stop it occurring in the first place. But then along came a class of drugs known as "biologics," which revolutionised treatment of this condition by eliminating part of the immune response that causes the joint inflammation in the first place, preventing it from developing into a permanent problem.

Curiously, people who had been placed on this treatment for many years to keep their arthritis at bay turned out to have an extremely low incidence of Alzheimer's dementia, compared to others of about the same age from a similar socioeconomic background, but who weren't treated with that type of drug. This begs the question: Could these biologic agents be holding back autoimmune effects also responsible for accelerating cognitive decline? At present, we still don't know for sure, but it *is* an exciting possibility.

Chapter takeaways

- Start applying the brakes now to delay age-related cognitive decline. You might not be able to stop it completely, but you certainly *can* slow it down.

- Don't let free radicals become bulls in your brain's china shop. Give healthy nutritious foods packed with antioxidants the upper hand and let them become a part of your daily diet.

- If you want to keep your brain maintained in full working order, it's vital that you look after the pump that keeps it pumped with everything it needs – your heart.

- Keep your pipes clear of obstructions. Take the stairs instead of the lift and when possible, leave the car behind, walking or cycling instead. Give smoking a miss and, if you haven't already done so, reduce your intake of red meat to an occasional treat.

- Stop the rust by keeping your brain's cogs well-oiled and turning smoothly with mind-stretching, social activities.

- Build cognitive reserve. Whether you take up a musical instrument, play chess, dance, read books, speak other languages, play table tennis or start juggling on one leg – do it regularly, push yourself harder and keep it up for the rest of your life!

What's Next?

You should now be more than aware of what you have in your possession. You are the owner, guardian and keeper of the most advanced and sophisticated super bio-computer ever created. How you use it, how you look after it and what you do with it is, of course, up to you.

The crystal ball of brain tech

Before we wrap things up with a whistle-stop tour of the highlights of this story of how to sort your brain out, we're going to take a quick peek into the future of brain technology. Reports and articles are published every week, breathlessly psyching everyone up to prepare for the latest brain-boosting device that's going to revolutionise everything. This section is all about setting matters straight on what's on the horizon. These devices either take information out of the brain and put it up on a screen so we can see how well we've exerted our powers of mind over matter, or they apply electrical or magnetic stimulation across the skull in an effort to stimulate or disrupt activity at the brain's surface. Both techniques have made some ground in the clinical setting, as a form of therapy or facilitated brain training for various neurological conditions, but neither are likely to come to be of much use in our everyday lives any time soon. Someday they may well make a difference to how we boost our brains with technology. Just not yet!

Neurofeedback describes the use of technology that enables people to visualise on a screen how well they are wielding their skills of mind over matter. Electrodes stuck to the scalp monitor what the brain's up to on

the other side of the skull. By detecting the electrical signals generated across the Frontal District and looking out for the telltale signs of improvements in their attempts to either focus their attention, relax their minds or even improve working memory, images are displayed on the screen to help them see when their efforts are paying dividends and when they're not quite hitting the mark.

Adrian's reflections

Three things that have really sunk home for me are the importance of:

- *Continuously keeping my brain challenged*
- *Keeping it fuelled with the right fuel*
- *Giving serious consideration to what my gut is telling me*

Feeling mentally sharper and with more consistent energy levels, I am now far better equipped for delivering my motivational talks and workshops. The best news is that when I arrive at home from travelling, I'm still up for some serious fun with the kids. And, much to the astonishment of my friends, I'm even getting out on my road bike a lot more. Having already completed my first charity ride, I'm now planning more adventurous ones.

What has surprised me is just how addicted I had become to checking my emails, text messages and tweets! As a businessman I'd be mad not to still check them regularly, but on an hourly basis rather than every few minutes.

In recent years I have become good at boxing off the work from play and have learnt to make time to be with my family and friends. With the knowledge I now have, I am currently focusing on regularly setting aside pure rest time to really wind down and give my brain a chance to catch up with those much-needed repair works.

– Adrian

Jack's reflections

At the end of the first edition I was mainly focused on how, as someone who played football once or twice a week and went to the gym once or twice per week too, not to mention the odd 10km cross-country run every fortnight or so, I used to think I could eat and drink whatever I wanted. I was forever indulging my impulses to eat delicious fatty stuff and fast-release carbs in the form of jam on toast, sugary cereals and chocolate bars, thinking that I'd burn it all off with my various activities. But I noticed that the metabolic goalposts move as you progress from your 20s into the 30s and then again from the 30s into the 40s. I realised that staying active wasn't enough to keep a healthy body weight. I really do need to eat healthy stuff habitually and keep the sweet treats for once in a while. What I've learned most recently is the importance of not just what you eat, but when you eat it.

Time-restricted feeding (one of the various styles of intermittent fasting) really didn't seem like my bag. The idea of not eating for twelve hours or more, to get the metabolism kicking into fat-burning mode, seemed like a bit of a chore. I hate being hungry (hangry!) and find it hard to focus on anything other than my need to top up my depleted sugar levels. But I found that if I organised my day a bit better, it works just fine!

I spent about a year getting into the habit of breaking my fast later and later, having breakfast a few hours after waking up rather than more or less straight away. If I eat my last nighttime snack at 9 pm, then I eat breakfast any time after 9 am. For the first few weeks I was clock watching until the appointed hour, but my body soon got used to it, and I found I could go until 10 am, 11 am, sometimes even midday before I really needed to eat.

Having spent many years marginally overweight (according to the body mass index) my weight is now in the healthy zone. My morning

(Continued)

productivity is better than it has ever been. And I am now safe in the knowledge that, while I've never looked particularly overweight on the outside, the weight I shed simply by doing all of the above, plus my usual exercise habits, is keeping all the lethal visceral fat around my organs at bay.

This was the final piece of the puzzle for me when it came to practising what I preach. I start each day reading books for an hour, for my brain's sake. I get all my coffee drinking done in the morning. I spend 10 minutes learning a second language every morning. I pick up my skipping rope to wake my brain up every time I put the kettle on. I pursue my stone-carving hobby on a regular basis (I'm still rubbish but I love spend hours locked into flow). When I get tired in the afternoon I routinely dip into hypnogogia with a restorative 10- to 20-minute nap. And I squeeze in my 10 minutes of daily meditation at the end of the day when my head hits the pillow.

If you're starting right from square one, and it seems like you've got a long way to go, rest assured that so long as you approach your lifestyle overhaul in terms of manageable bite-sized chunks, you WILL get there. You just need to be patient with yourself, don't beat yourself up about the inevitable slip-ups along the way and remember that the more you can do to look after your own brain, the better you'll be able to support the other people in your life and maximise your own potential.

– Jack

While there is much excitement in this field, at the moment the most promising results have come when it has been studied for its potential in helping various clinical populations to overcome symptoms relating to certain neurological conditions, like attention-deficit hyperactivity disorder and epilepsy. Only in these studies was there evidence for a long-lasting benefit from neurofeedback training and even then the improvements were only mild. You are unlikely to start seeing this kind of kit used at home or at work to boost brain function anytime

soon, but as this relatively new field of research continues to progress, don't be surprised if you start seeing it pop up more and more as the years go by.

Neurostimulation is another futuristic-sounding approach that is gathering momentum as the research looking into its potential starts to accumulate at a faster and faster rate. Again this involves sticking electrodes to the scalp, but this time instead of measuring the electrical activity produced by millions of neurons under the skull that comes *out* of the brain, a very weak electrical current is injected *in*to the brain. This technique is called transcranial direct current stimulation (tDCS).

The idea of doing this is not dissimilar to the surgical treatment for Parkinson's that uses electrodes to boost the weakened signal to help patients initiate their movements more easily. But the huge difference here is that, with deep brain implants used in Parkinson's treatment, these electrical impulses can be targeted very precisely to the brain area that needs a helping hand, while neurostimulation involving applying electrical currents at the surface of the head is not so easily directed to a specific part of the brain. The same goes for another popular technique using magnetic fields called transcranial magnetic stimulation (TMS). Either approach impacts the target brain area at the surface *and* all sorts of other nearby brain areas that you weren't aiming for. This muddies the waters considerably in terms of establishing how well these approaches work.

As with the neurofeedback research, TMS and tDCS have been mainly looked into for their potential in improving symptoms in various neurological conditions. Some success has been achieved in people with depression, migraine and chronic pain, for example, but scientists have also been dabbling with using these techniques to boost memory, attention and problem solving. Results are often mixed, with some studies finding it effective and others not, but as the methods improve and more research is done, this is another area of brain-boosting research that may well bear fruit in the years to come.

What could possibly hold anyone back?

During childhood your brain cells got wired together according to your own personal experience of the outside world and the people in it. The result is that each and every one of our brains is individually and uniquely moulded by whatever has gone on around us, by what we've seen, heard, touched, tasted, felt and smelled in innumerable different situations.

Young children have a natural, unbridled curiosity that encourages them to set off on a voyage of discovery to help gain a better understanding of the big and exciting world that surrounds them. As soon as a toddler begins to grasp the ability to speak, they'll be off on a relentless quest to find answers to anything and everything. With no mental barriers in their way and driven by an unstoppable need to know, their appetite for knowledge, as any parent will tell you, is ferocious. A survey once claimed that a typical four-year-old asks 437 questions a day – didn't realise it was so few!

The feedback children receive from their constant questioning has a critical impact on their ability to accelerate their understanding of the world around them, whether through information gained from older, more experienced humans, or what they learn first-hand through their own trial-and-error exploits. Through both these mechanisms a set of beliefs about how the world works begins to form. They also start to develop beliefs about themselves. These self-beliefs start to develop over the course of early childhood with the feedback their brains take on board being key to their formation.

To start with, our beliefs are easily moulded but, as the years go by, they slowly start to firm up. Gradually they become less flexible, until in old age they all too often appear to become as solid as reinforced concrete and invariably provide the firm foundations of a deeply entrenched outlook.

Self-beliefs, whether formed through information obtained from adults or through our own exploratory adventures, are rarely accurate representations of reality.

The feedback we received and the impact it had

"Sticks and stones may break my bones but words will never hurt me" may have afforded many children some degree of comfort over the years but, as far as our brains are concerned, this old ditty could not be further from the truth.

It's a sad fact that much of the feedback we received as children was misguided, inaccurate, misinterpreted or plain wrong. Just a few ill-considered, ill-timed, spur-of-the-moment, negative comments from an influential person can trigger a nosedive in self-belief. And once you start to believe something it can really stick, as a psychological phenomenon known as *confirmation bias* sets in.

Confirmation bias describes a filtering mechanism of your brain that registers and accepts certain information and rejects others. Specifically, it tends to agree with whatever you already believe and rejects that which goes against your preexisting beliefs. So if, for example, based on comments made to you when you were young and impressionable, you came to accept that you were a hopelessly uncoordinated dancer, then over the years you're likely to have developed the unfortunate tendency to unquestioningly accept any evidence that this is true and ignore anything that refutes it.

Can't hear you!

Just how desperately some people hang onto their existing beliefs was demonstrated when an experiment was carried out with people who held strong political beliefs.

They were shown film footage of the leaders of their favourite political party and also their least favourite party. The two leaders

(Continued)

were making speeches in which they both totally contradicted themselves. When interviewed afterwards, the participants seemed completely oblivious to the contradictions made by their favoured politician but were scathing about the inconsistencies they spotted in the opposition party leader's speech. Why let a few simple facts get in the way of a firmly held prejudice!

In another experiment, participants were played recordings of people talking about religious beliefs. Some recordings were in direct contradiction to their own, and others were in line with their preexisting religious beliefs. They had the opportunity to drown out what they were listening to by turning a dial to increase the volume of some static noise. Most happily took the opportunity to add noise, but only to the recordings that went against their prior beliefs!

Repetition rules

Should a certain theme crop up again and again, that's when a young person's self-belief can really start to get backed up into a cul-de-sac. Blocked in and perhaps a bit dented, they may well find themselves unenthusiastic about venturing out of their comfort zone for fear of further negative repercussions.

When the feedback we received in childhood was wrong, inaccurate or misleading, we can find ourselves believing that we are good at things that in reality we are not (think of some of those poor deluded souls who audition for certain TV talent shows) or that we are bad at things that in reality we could have become very good at. Thankfully, life usually sets matters straight in the former instance, but unfortunately not nearly so often in the latter.

The vast majority of people think they are useless at certain things that they could still possibly be brilliant at. Countless numbers of people

go through life blissfully unaware that they have been held back early on in life, never getting the chance to realize their true potential. Simply because certain "grown-ups" had a habit of repeatedly making misguided, negative, flippant remarks, the person on the receiving end of this may unwittingly have become prisoners of other people's thinking.

More often than not such comments are made by adults in an attempt to vent personal frustration rather than to give a fair assessment. Whatever the motive, the long-term effects can be both damaging and profound. Bearing in mind the very people making the comments may well have had their own self-belief knocked and dented somewhere down the line, it's easy to see how a negative cycle can develop. When a person has damaged self-belief, admitting that others are better than them at something can at times be too much to bear and so, sadly, some form of nitpicking criticism replaces the deserved praise.

The consequence is that, many years later, when a past recipient of such inaccurate feedback comes to perform the task they were previously criticised about, they stumble. That voice in their head says, as it always does on such occasions, "You've never been any good at this!"

The fact that the personal feedback we received during childhood wasn't always true to reality was, for us as children, completely unavoidable. It obviously varies considerably, being far worse in some childhoods than others, but whether you realize it or not, we've all had our fair share of inaccurate feedback somewhere along the way.

To be absolutely clear here, the odd comment now and then will not harm a child's long-term prospects; most kids are pretty resilient on the whole. And, as far as adults are concerned, a negative comment here and there might be just the wakeup call needed to motivate them to kick off their slippers and get moving.

Problems only arise when a certain theme is repeated regularly throughout childhood. Even seemingly innocuous playful teasing can eventually get under their skin if it is essentially knocking a child's capabilities

on a regular basis. Repetition is what causes the cement to set badly. That's when an adult's "harmless" comments begin to make a seemingly indelible impact on young impressionable minds, flavouring all future experiences.

Photo albums

When we experience anything, we never get the full picture all in one go. Instead we take away lots of small, snapshot pictures of different parts of the experience. Think about what you did yesterday: you won't be able to picture the whole day, but you will have several pictures of different significant events. These snapshots all combine and build up together in your brain to form much larger, jigsaw-style images of how the world works and how we fit into it. These big pictures will never, ever be complete because of the scale and complexity of life around us and limitations in our brain's ability to take it all in. There will always be pieces missing. With our brains having nothing else to go on, this is what our beliefs are based on.

What really counts when it comes to forming and reinforcing self-beliefs is that certain consistent themes are encountered that knock our confidence. When these similar snapshots formed by seemingly objective feedback keep cropping up over and over again, it selectively reinforces those same old familiar perspectives on what we are not so good at and eventually becomes accepted as fact – a fact that might feel true, but "facts" from misleading sources are fictions. And there's no need to let such fictions hold you back from now on.

That's because, each time we revisit a memory, we subtly rewrite it. This can cause absolute havoc in court cases, because witness testimony becomes less and less reliable as detectives question them about the incident over and over again, repeatedly making suggestions about what "might" have happened. It can lead people to start recalling details that were never in their original memory! But for the rest of us this quirk of human memory presents a fantastic opportunity.

If we can prime ourselves with positive thinking before we revisit unpleasant past experiences, we can potentially rewrite our memories in a way that gives us a more positive outlook or at least changes the emotional tone of those memories to stop them holding us back. By getting in the habit of repeatedly telling ourselves more positive stories, inspiring ourselves with examples of brain change heroes who did change their ways, using techniques that anyone can use, we can start to boost our self-belief.

Memories are formed of peak and recent experiences

Would you believe that studies have shown that people actually end up with less harrowing memories of a painful medical procedure if it takes longer – just so long as the most intense peaks of pain and/or the very last experiences of the pain are less painful than in the shorter version?

This is because the memory of any experience is formed chiefly from the highlights. However, as the memory of an event is constantly updated, much of the previous information is overwritten by the very last thing. Which is why the ending of a holiday, movie or painful experience has such a powerful impact when you look back on it.

Your brain will change according to the consistent messages it receives from the outside world and during your mind-wandering excursions. Self-beliefs will improve if you regularly tell yourself stories that make you feel positive and uplifted.

Advertising companies are more than aware of this; they know that good branding is all about consistent messages presented in novel, unusual and emotionally stimulating ways. It has been estimated that, on average,

each one of our brains is exposed to up to 5,000 ads per day. Most are just a background blur, with only 1% having any conscious impact. That 1% may not sound like a lot but that's up to 50 marketing messages a day that might influence your future decisions.

Like it or not, this nonstop bombardment of messages does have an influence on our decision-making, hence companies spend such vast sums of money on it. Ad campaigns are most effective when the message a target audience is picking up on is consistent and coming at you from all directions. As with your self-beliefs, beliefs regarding the relative quality of different brands are also forged through the reinforcing power of repetition. A healthy scepticism about these messages comes highly recommended. And limiting your exposure makes sense too.

Believing is seeing?

Tragically, self-belief for the vast majority of people does tend to stay blocked in.

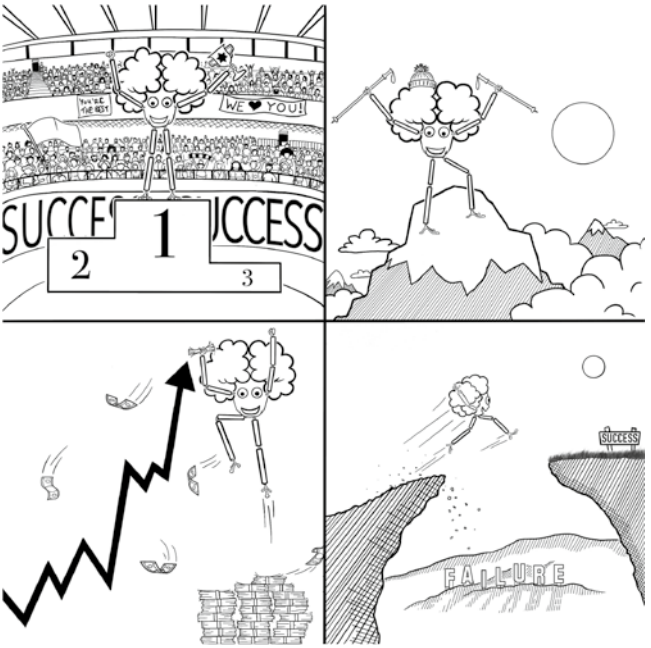
There are, however, exceptions.

They are individuals who have realized that they don't have to watch others achieve great things to realize they can be achieved.

As believers in life before death, they are ordinary people who achieve extraordinary things. They get out there, make the most of whatever talents they have, smash open long-held, restrictive beliefs, push back boundaries, turn current thinking on its head, really make a difference – then watch others follow.

You have the keys to the world's fastest high-performance engine. If you want to keep on driving up and down the same streets and remain within limits set by others, that's fine. It's your brain and it's your choice. But what a waste!

Hopefully, having read this book, you'll be curious to discover more about your own brain. You'll be inspired to want to open up the throttle to find out for yourself just what that precision-tuned, pulsating pink blob between your ears is *really* capable of!



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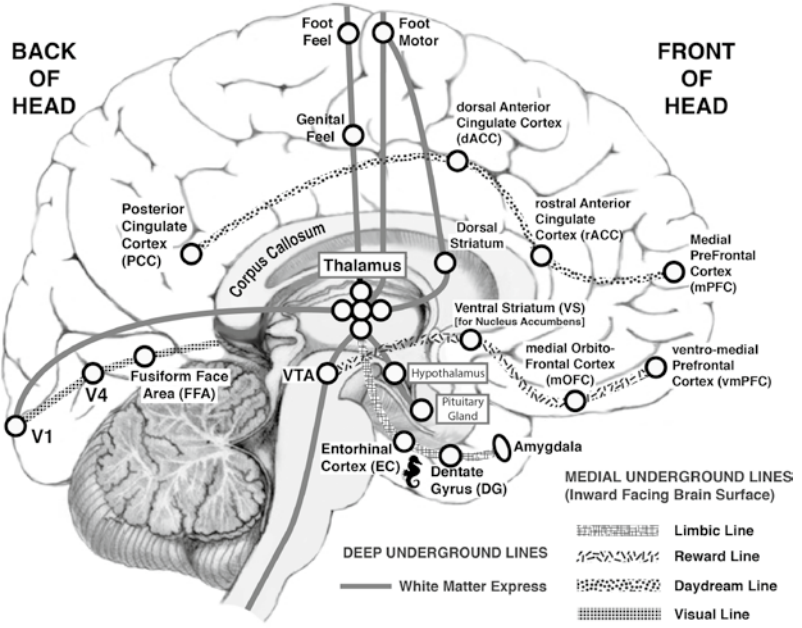
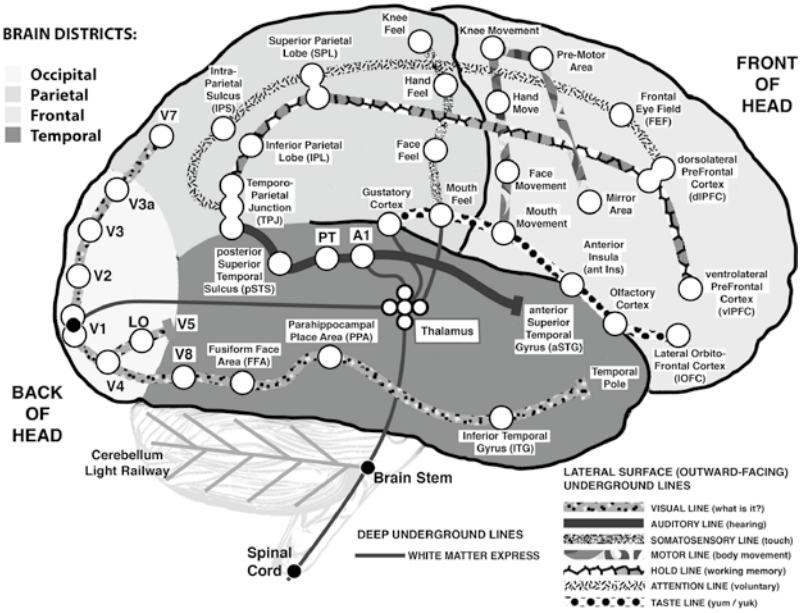
For references, please go to www.sortyourbrainout.com

Appendix: Brain Tube Maps for Easy Reference



This is the inward-facing brain tube map representing stops along the "inner" surface of the brain, where the left and right brain hemispheres rub against each other.



This is the outward-facing brain tube map showing stops along the "outer" surface of the brain, just beneath the skull.

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I would like to dedicate this edition to my amazing parents, Phil and Virginia Lewis. They've been so incredibly supportive for so many decades. I feel incredibly grateful to have been on the receiving end of so much love, patience and wisdom. "So long as you can say to yourself that you've given it your best, then that's all we ask," was a mantra that has got me through many challenging circumstances. A big shout-out also to my sister, Mel, an incredible brain in her own right and my brilliantly talented brother, Dave, who kindly did all the illustrations for this, the second edition. Both my siblings have flourished into such lovely people and I value their friendships enormously.

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Thanks also to you, the reader. I appreciate you taking the time to read this and hope you get something good out of it. If you like it, don't be shy, let me know: @drjacklewis

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Dr Jack Lewis

Dr Jack Lewis has a first-class neuroscience BSc from the University of Nottingham, a master's degree in virtual reality from the London College of Communication and a PhD in neurobiology from University College London. His post-doctoral research, conducted at the Max Planck Institute for Biological Cybernetics, explored multisensory perception using functional Magnetic Resonance Imaging studies that were published in the *Journal of Neuroscience*. Regular speaking engagements have enabled Jack to motivate and inspire a wide variety of audiences from businesses (including Boehringer Ingelheim, Deloitte, ITV, Microsoft, Siemens and Warner Bros.) and science festivals to a wide variety of educational establishments from schools to universities. He has also helped to make the pearls of wisdom fished out of the neuroscience literature more accessible, compelling and personally relevant for global audiences of millions via television programmes on BBC, ITV, Ch4, Ch5, Sky, Discovery, TLC, Nat Geo, MTV and most recently two series of *Secrets of the Brain* on Insight TV.

For more information about Jack – please visit www.drjack.co.uk or follow him on Twitter at @drjacklewis

Adrian Webster

Milkman, policeman and salesman were just a few of the entries on Adrian's CV before he moved into the IT industry and discovered an ability to inspire everyday people to achieve extraordinary results.

The son of a Yorkshire coal miner, he is now an international best-selling business author and one of the most popular motivational speakers in Europe today, delivering keynote presentations around the world.

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About the Illustrator

Dave Lewis graduated with a degree in biology from the University of Manchester in 2006, before going on to build a career as an intelligence analyst for the creative industries. Specialising in IP and copyright protection across the sport, entertainment and film industries, Dave has always created work involved in bringing to life complex data sets via simple, easy-to-digest visualisations. Dave's love of illustration and design also encouraged him to continue to pursue it in his spare time, training in the art of drawing and graphic design whilst continuing to be inspired and entertained by the likes of cartoonist David Squires. So when his brother (Dr Jack) began work on this second edition of *Sort Your Brain Out,* it seemed like the perfect opportunity to bring together Dave's skills from a career visualising complex concepts with his personal love of design. So, if you like the illustrations in this book, see @DaveLewisDesign on Instagram for more!

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